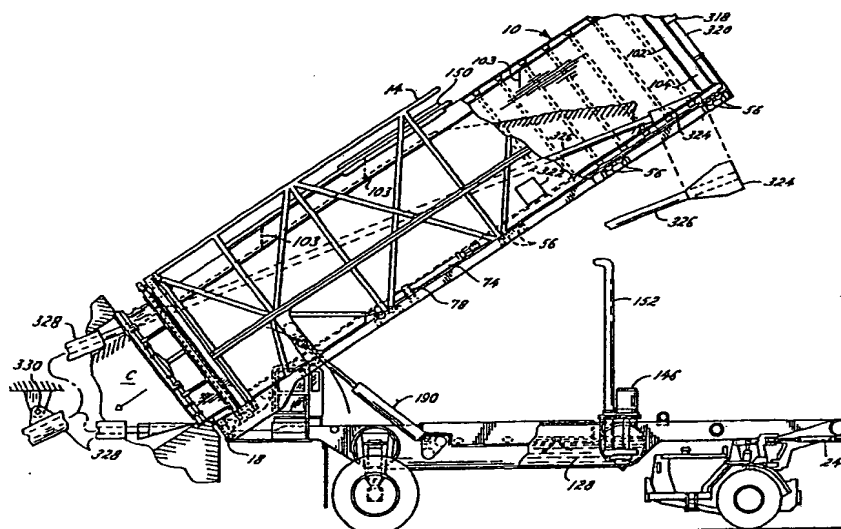




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(54) Title: METHOD AND APPARATUS FOR HANDLING AND DRY QUENCHING COKE



## (57) Abstract

A method and apparatus for handling and dry quenching coke comprises a coke box (10) for receiving and dry cooling a coke charge from a coke oven in a pollution-free manner and a self-propelled carrier vehicle (12) having four-wheel steering capability for transporting the coke box. The carrier vehicle includes a lower main frame (16) and an upper tilt frame (14) for supporting the coke box and being pivotally connected (18) by a pivot shaft (190) for discharging the dry cooled coke charge from the coke box or the coke box containing the coke charge. The carrier vehicle is provided with hydraulic cylinder assemblies (52, 74) for maneuvering the position of the coke box supported within the upper tilt frame for alignment with the face of a coke oven for receiving a coke charge and for locking the position of the coke box with respect to the tilt frame during charging and discharging of the coke charge. The carrier vehicle is equipped with a water cooling system for cooling the exterior surfaces of the coke box and an inert gas cooling system for circulating gas within the coke box.

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"Method And Apparatus For Handling and Dry Quenching Coke"

FIELD OF THE INVENTION

The present invention relates generally to a system for dry quenching coke and more particularly concerns a coke box used for transporting and dry quenching the hot coke and a specialized vehicle for picking up and transporting the coke box.

BACKGROUND OF THE INVENTION

When coal is cooked in very high temperature ovens in the absence of oxygen, the heat transforms the coal into coke which is then used as a fuel in blast furnaces to produce steel. After the coal has been turned into coke by the "coking process," it must be cooled before being sized for use in the blast furnaces. In conventional coking operations, the hot coke cake is expelled by a ram into hopper cars open to the atmosphere where it ignites and continues burning until hot coke is quenched, typically by running the cars through a water bath to lower its temperature below the kindling temperature.

Several problems result from conventional coking operations. First, expelling the hot coke into the hopper cars pulverizes and breaks the semi-rigid coke cake into chunks smaller than the minimum acceptable size for use in the blast furnace operation. Secondly, the burning coke causes a loss of valuable coke and air pollution from the combustion fumes.

Quenching the burning coke with large quantities of water creates additional problems. For example, a major disadvantage with water quenching is that the wet coke has a substantially lower heating value than dry coke. Further, there is significant air pollution from the dust particles and chemicals that are carried into the atmosphere with steam that is formed when the water strikes the hot coke. Not only

is the water polluted by the coke, but the coke itself is polluted by chemicals in the waste water that is typically reused in the quenching process. Finally, the quenching operation itself causes the coke to break up, further pulverizing and degrading the quality of the coke.

There have been numerous attempts by others to overcome some or all of the general problems associated with conventional wet quenching, some dating back to the nineteenth century. Approaches have included receiving the coke in substantially cake form, following by either direct or indirect water quenching. An example of the former is U.S. Patent 3,748,235 to Pries, while examples of the latter are German Patent 279,950 and U.S. Patent 4,285,772 to Kress. There have been several proposals involving the use of inert cooling gas to quench hot coke in closed containers. Examples of such arrangements are shown in British Patent 183,113 (1923), in German Patent 436,995 and in the Kress patent referenced above.

The Kress patent discloses a system employing a trackless, steerable vehicle which is adaptable for either grass roots coking operations or existing coke oven batteries. The present invention presents improvements on the basic system and vehicle disclosed in U.S. Patent 4,285,772.

It is an object of the present invention to provide an improved coke box and system for manipulating the coke box.

It is a further object of the present invention to provide an improved coke box carrier vehicle with increased maneuverability.

A more specific object is to provide a carrier vehicle which can manipulate the coke box in order to

accurately align it with the oven with a minimum amount of maneuvering of the carrier vehicle itself.

Still another general object is to provide a water cooling system which may be used either on the carrier vehicle or a remote cooling rack. Similarly, it is an object to provide an inert cooling gas system which may also be used either on the carrier vehicle or a remote cooling rack.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a plan view of a coke box and carrier vehicle according to the present invention aligned with a coke oven and in position to receive a charge of coke;

FIG. 2 is a side elevational view of the coke box and the carrier vehicle of FIG. 1;

FIG. 3 is a plan view of the coke box of FIGS. 1 and 2;

FIG. 4 is a side elevational view of the coke box of FIGS. 1 and 2;

FIG. 5 is an elevational view of the same coke box and the carrier vehicle taken through the plane 5-5 in FIG. 2;

FIG. 6 is an enlarged, fragmentary elevational view of the same coke box and carrier vehicle taken through the plane 6-6 in FIG. 4;

FIG. 7 is an enlarged, fragmentary sectional view of the tilt frame shifting assembly taken through the plane 7-7 in FIG. 5;

FIG. 8 is an enlarged, fragmentary sectional view of the tilt frame shifting assembly taken through the plane 8-8 in FIG. 7;

FIG. 9 is an enlarged, fragmentary sectional view of a clamping assembly taken through the plane 9-9 in FIG. 7;

FIG. 10 is an enlarged, fragmentary sectional view of a coke box holding assembly taken through the plane 10-10 in FIG. 2;

FIG. 11 is an enlarged, fragmentary sectional view of the coke box holding assembly taken through the plane 11-11 in FIG. 10;

FIG. 12 is an enlarged, fragmentary sectional view of the coke box holding assembly taken through the plane 12-12 in FIG. 10;

FIG. 13 is an enlarged, fragmentary sectional view of the coke box roller assembly taken through the plane 13-13 in FIG. 7;

FIG. 14 is an enlarged, fragmentary sectional view of a coke box roller assembly taken through the plane 14-14 in FIG. 13;

FIG. 15 is an enlarged, fragmentary sectional view of the coke box engaging the coke oven taken through the plane 15-15 in FIG. 6;

FIG. 16 is an enlarged, fragmentary sectional view of a door shifting assembly taken through the plane 16-16 in FIG. 6;

FIG. 17 is front elevational view of a door plate;

FIG. 18 is an enlarged, fragmentary sectional view of the door plate taken through the plane 18-18 in FIG. 17;

FIG. 19 is an enlarged, fragmentary elevational view of an oven seal assembly taken through the plane 19-19 in FIG. 15;

FIG. 20 is an enlarged, fragmentary sectional view of a seal plate retainer of the oven seal assembly taken through the plane 20-20 in FIG. 19;

FIG. 21 is a schematic depiction of a tiller bar steering arrangement;

FIG. 22 is an enlarged, fragmentary sectional view of an arrangement for cooling the coke box taken through the plane 22-22 in FIG. 4;

FIG. 23 is an enlarged, fragmentary sectional view of an arrangement for cooling the coke box taken through the plane 23-23 in FIG. 4;

FIG. 24 is an enlarged, fragmentary detailed view of an upper portion of FIG. 22 showing a water gap;

FIG. 25 is an enlarged, fragmentary, detail view of the water gap of FIG. 24;

FIG. 26 is an enlarged, fragmentary sectional view of the water gap taken through the plane 26-26 in FIG. 24;

FIG. 27 is an enlarged, fragmentary sectional view of coke ox wall tension bands taken through the plane 27-27 in FIG. 4;

FIG. 28 is an enlarged, fragmentary sectional view of the coke box wall tension bands taken through the plane 28-28 in FIG. 27;

FIG. 29 is an enlarged, fragmentary sectional view of coke box pressure vents taken through the plane 29-29 in FIG. 4;

FIG. 30 is an enlarged, fragmentary sectional view of coke box pressure vent taken along the plane 30-30 in FIG. 29;

FIG. 31 is an enlarged, fragmentary sectional view of a lower catch trough and drain weir of the cooling system taken through the plane 31-31 in FIG. 4;

FIG. 32 is an enlarged, fragmentary sectional view of gate valves taken through the plane 32-32 in FIG. 31;

FIG. 33 is an enlarged, fragmentary sectional view of the gate valves in a closed position taken through the plane 33-33 in FIG. 32;

FIG. 34 is an enlarged, fragmentary detailed sectional view of a gate valve shown in an open position taken through the plane 34-34 in FIG. 33;

FIG. 35 is a side elevational view showing the tilting of the coke box and carrier vehicle to empty a load of cooled coke at a coke crushing station;

FIG. 36 is a plan view of the tilt frame and the inert cooling gas system;

FIG. 37 is a side elevational view of the tilt frame and inert cooling gas system of FIG. 36;

FIG. 38 is an enlarged, fragmentary sectional view of the coke box vent taken through the plane 38-38 in FIG. 36;

FIG. 39 is an enlarged, fragmentary sectional view of the heat dissipation system taken through plane 39-39 in FIG. 37;

FIG. 40 is an enlarged, fragmentary sectional view of the heat dissipation systems taken through the plane 40-40 in FIG. 40.

FIG. 41 is a fragmentary plan view of an apparatus to assist in aligning the coke box with the coke oven;

FIG. 42 is an elevational view of the aligning apparatus of FIG. 41.

While the invention is susceptible to various modifications and alternative constructions, certain illustrative embodiments have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but on the contrary, the intention is to cover all modifications, alternative



constructions and equivalents falling within the spirit and scope of the invention as defined by the appended claims.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to improvements in the coke box itself and the apparatus for manipulating it to receive, cool, transport and discharge the coke. It is contemplated the the apparatus for manipulating the coke box operate either on tracks along the discharge end of a coke oven battery or as a wheeled, trackless vehicle. The preferred embodiment discussed below and illustrated in the drawings is a wheeled, trackless vehicle.

Turning to the drawings, there is shown in FIGS. 1 and 2 a plan view and a side elevational view, respectively, of a preferred embodiment of the invention comprising a coke box 10 and carrier vehicle 12 which are employed together to receive a charge of coke in the form of a cake C from the coke oven O. A conventional ram R, shown in phantom in FIG. 2, is employed to push the coke from the oven O and into the coke box 10.

The carrier vehicle 12 includes an upper tilt frame 14 pivotally connected to the lower main frame 16 by a pivot shaft 18 located at the forward end of the carrier vehicle 12. The carrier vehicle 12 is designed to accommodate the limited maneuvering space available in many coking facilities. To this end, the main frame 16 is supported by a rear prime mover 20 and front wheels 22. A steering actuator 24 interconnects the main frame 16 and the prime mover 20 for pivoting the prime mover 20 relative to the main frame 16 about the vertical axis 26 that passes close to the axis of the prime mover ground wheels 28

so that the prime mover 20 can be turned substantially at right angles to the main frame 16 as shown in phantom in FIG. 1. This arrangement gives the vehicle 12 extremely good maneuverability by allowing the main frame 16 to turn substantially within its own length. The forward wheels 22 are also steerable. The wheels 22 are connected together via a tie rod 30 which is controlled by a steering actuator 32 as shown in FIG. 5. Struts 34 connect the wheels 22 and tie rod 30 to the main frame 16 and serve as pivot points during turning. This arrangement permits "crab-type" steering, which greatly enhances maneuverability.

At the end of the coking operation for a particular oven, the carrier vehicle 12 with the coke box 10 in place is driven into position so that the coke box 10 is substantially aligned with the coke oven O. As illustrated in FIG. 5, the position of the cab 36 provides an excellent view for the operator to align the coke box 10 with the coke oven O. Sights and alignment aids, discussed in more detail below, may be employed to aid in accurately aligning the coke box with the coke oven.

The accurate alignment of the coke box with the coke oven is important in minimizing the force required to push the coke from the oven into the coke box. Specifically, the alignment must be accurate within a couple centimeters. In view of the fact that a vehicle of the type illustrated can be on the order of 20 meters long, 8 meters wide and 10 or more meters high, alignment to such an accurate degree in a short period of time can be a formidable task. As noted above, the vehicle is highly maneuverable in view of its all-wheel steering capabilities. It has been found that separate tiller-bar steering controls

with each indicating the instantaneous direction of the respective sets of wheels, enhances the ability of the operator to quickly recognize and effect an appropriate steering adjustment. Such a system is depicted in FIG. 21. It should be noted in that figure that the tiller-bar 300 for controlling the forward wheels 22 is oriented the same as the wheels themselves, while the tiller-bar 302 for controlling the rear wheels 28 is independently oriented the same as those wheels.

A further alignment aid is shown in FIGS. 41 and 42. The aid consists of a forwardly-extending horizontally-pivotable probe 304 which interacts with a receptacle 306 at the coke oven to indicate the existence and extent of any lateral misalignment. The probe is telescoping so that, as the vehicle moves closer to the coke oven face, the probe is progressively compressed.

In the embodiment shown the receptacle 306 on the face of the coke oven O is fabricated to be V-shaped, and the probe has a roller 308 mounted on a vertical axis. In the event the probe 304 contacts the receptacle 306 off center, the probe will center itself by pivoting about the axis. This pivoting is sufficient to cause one of elements 310 on the rear of the probe to contact one of the microswitches 312. These microswitches in turn operate the side shifting cylinders 52 to shift the tilt frame (and the coke box therein) in the direction necessary to return the probe to a centered orientation. In this manner, the necessary side-shifting can be automatically accomplished during the final approach without the need for independent input from the operator.

In addition, the coke box may be provided with one or more contact-activated switches 314 which indicate when the coke box is in the correct orientation relative to the oven opening. It will be appreciated that four such switches, one near each corner of the open end of the coke box, can be employed to provide an indication of correct alignment, as by illuminating an indicator light when each switch is made.

Other alignment aids, such as sights, mirrors, light beams, and gyroscopes may also be employed to facilitate the final alignment of the coke box with the coke oven.

The coke handling system of the present invention may also be equipped with an alignment interlock to provide a signal confirming that alignment has been achieved and is being maintained. Such an interlock may be of a known type which completes a pneumatic circuit during alignment. Referring to FIG. 42, a pneumatic port 316 may be provided in the coke oven face over which a mating pneumatic port 317 carried by the vehicle can be applied when alignment is achieved. Once the mating is achieved, pneumatic pressure can in turn be employed to signal the operator of the ram at the other end of the furnace that pushing may commence. Conversely, should the pneumatic interlock circuit be broken at any time during the push, the signal will be lost and advance of the ram may be halted or otherwise adjusted as appropriate.

An optional system for clamping and aligning the carrier vehicle 12 and the coke box 10 with a conventional coke oven 0 having a coke bench B is illustrated in FIGS. 8 and 9. Such a clamping system may be used to supplement the vehicle wheel brakes

(not shown) to prevent the carrier vehicle 12 from inadvertently being pushed away from the oven O during the pushing operation when the ram R pushes the coke cake C into the coke box 10. Thus, to prevent sliding, the clamping system secures the forward end of the main frame 16 to the coke bench B located at the base of the oven O.

In order to secure the main frame 16 to the coke bench B, the carrier vehicle 12 approaches the coke bench B and the main frame 16 is raised so that there is sufficient clearance between the main frame 16 and the coke bench B. The forward position of the main frame 16 is raised by a pair of pivotable, extendable struts 34 which also serve as the pivots for the front steering wheels 22 as shown in FIG. 1. The struts 34 may be of the type disclosed in U.S. Patent 3,820,818 to Kress. The rear portion of the main frame 16 is similarly raised by a lifting actuator 38 associated with the rear prime mover 20. The lifting and steering operations may be controlled by the operator stationed in the cab 36 of the carrier vehicle 12. When the main frame 16 is resting on the coke bench B, the weight of the vehicle 12, coke box 10, and ultimately the coke C is shared between the coke bench B and the carrier vehicle 12.

Once the main frame 16 is resting on the coke bench B, the clamping system can secure the vehicle 12 to the outboard guide rail G. The clamping system, illustrated in FIGS. 7 and 9, comprises a frame clamping bar 40 rigidly connected to the bottom of the main frame 16 and a pinching actuator 42 pivotally connected to the main frame 16. The actuator 42 controls a pinching lever 44 shown in phantom in the open position in FIG. 9. The pinching lever 44 is pivotally connected to the actuator 42 by

a pin 46 and to the main frame 16 by a pin 48. Thus, the actuator 42 can pivot the pinching lever 44 about pin 48 to open and close the clamping assembly. The pinching actuator 42 grabs the coke bench guide rail G between the pinching lever 44 and the frame clamping bar 40, securing the carrier vehicle 12 to the coke bench B. When the main frame 16 is secured to the coke bench B, the carrier vehicle 12 cannot inadvertently slide away when the coke box 10 accepts a charge of coke C from the coke oven O.

Additionally, this arrangement maintains the coke box 10 in a relatively aligned position with the coke oven O.

The coke box 10 is carried on the vehicle 12 within the tilt frame 14. The tilt frame 14 has an inner portion 50 to position the coke box 10 within the vehicle 12 and to guide the coke box 10 on and off the vehicle 12 (discussed below). The entire tilt frame 14 is slidably mounted on the pivot shaft 18 for lateral movement relative to the main frame 16 such that the alignment between the coke box 10 and coke oven O can be "finely tuned" using a front and rear pair of side-shifting actuators 52, illustrated in FIGS. 7 and 8. The actuators are rigidly mounted on either side of the main frame 16 to slide the tilt frame 14 along the pivot shaft 18.

In order to permit the coke box 10 to be readily rolled back and forth along the inner frame 50, as well as to be rolled onto and from the vehicle, the coke box 10 is carried by a driveable roller 54 and a plurality of idler rollers 56 on the inner frame 50 as shown in FIGS. 7, 8, 10, 13, 14, 22 and 23. It is contemplated that, during the maneuvering of the vehicle 12, the coke box 10 be in the retracted position shown in phantom in FIGS. 1 and 2. As a

result of the roller arrangement, however, the coke box 10 can roll forward relative to the tilt frame 14 to engage the coke oven O and permit a ram R to push the coke C into the coke box 10. In the embodiment shown, as best seen in FIG. 31, the idler rollers 56 are rotatably mounted on the tilt frame 14 substantially in the center of the inner frame 50. The idler rollers 56 have a central flat 58 flanked by flanges 60 to mate with and guide rail 62 mounted to the bottom of the coke box 10, thus assuring proper alignment and added stability of the coke box 10. To restrain the coke box 10 against horizontal movement, a plurality of upper guide rollers 64 mounted to the top of the inner frame 50, illustrated in FIG. 22, are rotatably attached to the upper portion of the coke box 10 such that they engage horizontal rails 66 to maintain the coke box 10 in a vertical orientation.

One mechanism for powering the coke box 10 along the inner frame 50 and on and off the vehicle 12 is the power driven roller 54 shown in FIGS. 7, 13 and 14. A hydraulic cylinder 68, pivotally mounted to the tilt frame 14 by a pin 70, raises and lowers the power driven roller 54, also pivotally mounted to the tilt frame 14 by a pin 72, to engage and disengage the rail 62 projecting from the bottom of the coke box 10 as needed. When the power driven roller 54 engages the rail 62, the roller 54 can position the coke box 10 along the inner frame 50 to load and unload the coke box 10 from the carrier vehicle 12, and to engage and disengage the coke box 10 from the coke oven O.

It will be appreciated that the coke box 10 must be secured to the tilt frame 14 during loading to prevent the action of the ram R and the coke cake C

from causing the coke box 10 to slide along the inner frame 50. Similarly, the coke box 10 must be secured while unloading the cooled coke C into a sizing station so that the coke box 10 will not roll off the raised tilt frame 14.

The mechanism for securing the coke box 10 to the tilt frame 14, as well as a second mechanism for shifting the coke box 10 relative to the tilt frame 14 is shown in FIGS. 10 through 12. The mechanism comprises a pair of telescoping cylinders 74 pivotally mounted by a pin 76 on either side of the inner frame 50 and a pair of actuating cylinders 78 located such that actuating cylinders 78 can pivot the cylinder 74 to engage and disengage a pair of trunnion pins 80 projecting from either side of the coke box 10. One end of the cylinder 74 has a ramp 82 with a hole 84 to positively lock the trunnion pin 80, as illustrated in phantom in FIG. 10, thus securing the coke box 10. The ramp 82 may telescope in and out to position the coke box 10 along the inner frame 50 as desired.

Once the main frame 14 is securely clamped to the coke bench B, and the coke box 10 is accurately aligned with the coke oven O, either the cylinders 74 or the power driven roller 54 may be employed to advance the coke box 10 to engage the coke oven O to receive a charge of coke C.

As disclosed in U.S. Patent 4,285,772 referred to above, and as illustrated best in FIGS. 3, 4, 22 and 23, the coke box 10 is rectangular in shape and has a volume slightly greater than that of the coke charge C to be received. Thus, the coke cake C may be pushed by a ram R from the coke oven O into the coke box 10 without significantly changing the shape of the coke cake C. With such an arrangement, the



pulverization which would otherwise occur when the coke C is pushed into a conventional hopper car is minimized. An additional advantage of this arrangement is that the large surface area of the thin, rectangular coke box 10 is conducive to efficient cooling, either through the coke box 10 surfaces or via an internally circulated inert gas, discussed below. As best illustrated in FIG. 2, the coke box 10 may be made somewhat longer than the initial length of the coke charge C in order to accommodate any crumbling of the leading edge of the coke charge C as it is pushed into the box 10.

As also disclosed in U.S. Patent 4,285,772, it is desirable for the coke box 10 to be substantially air-tight to prevent ignition of the hot coke C. Moreover, an oven seal arrangement, shown in FIGS. 15 and 19 through 21 and discussed in more detail below, is provided to create a substantially sealed relationship between the coke box 10 and the coke oven O during the pushing operation. Thus, during the pushing operation and thereafter, ignition of the hot coke C from the coke oven O is prevented. The air-tight coke box 10 also prevents substantially all the particulate matter from escaping to cause air pollution.

According to an aspect of the present invention, provision is made to allow the sides of the coke box 10 to expand and contract during the wide thermal swings which the coke box 10 experiences. In the embodiment shown, the coke box 10 comprises a receiving chamber 86 made of relatively thin metal panels 88. External support posts 90, spaced from the sides and bottom of the receiving chamber 86, provide the necessary support for the panels 88 without rigid or permanent interconnection

therewith. A plurality of support posts 90 shown in FIGS. 3 and 4, are placed along the length of the coke box 10. A plurality of connecting members 92 placed on the posts 90 support the receiving chamber panels 88.

The opposite ends of each connecting member 92, shown best in FIGS. 27 and 28, are fixed to the panel 88 with the connecting member 92 surrounding the associated support post 90 to provide the necessary support for the panels 88 without rigid or permanent interconnection with the support post 90. A T-bar 94 is shown rigidly connected to the post 90 and extending substantially the entire length of the support post 90 and panels 88. A spring 96 is shown disposed between the interior of the connecting member 92 and the exterior of the support post 90 to permit the restrained flexing of the receiving chamber panels 88. Each spring 96 is maintained in position with a boss 98 shown fixed to the band 92. In the event that it is desired to limit or prevent the movement of the panels 88 relative to the posts 90, the bosses 98 may be replaced with bolts 97 to selectively overcome the force of the springs 96. It will be appreciated that the T-bars 94 serve as stand-offs to provide support for the chamber panels 88 with minimal contact area. The outside radius of the T-bar 94 resting on the panel 88 permits meniscus wetting around the contact point 99 between the T-bar 94 and the panels 88. This arrangement permits the substantially unrestricted circulation of the cooling medium discussed in more detail below.

According to another aspect of the invention, in order to compensate for pressure changes within the receiving chamber 86, relief pressure vents 100 are provided at each end of the coke box 10. A baffle

swing plate 102, disposed within the receiving chamber 86 and between the rear pressure vent 100 and the coke C as shown in FIGS. 2 and 35, maintains a clear path 104 for any gasses to escape.

Turning to FIGS. 29 and 30, an embodiment of pressure vents 100 is illustrated which includes caps 101 which rest in sand S and over open tubes 103 welded into the top of receiving chamber 86. The sand S contained in a sand reservoir 105 centered with respect to the tubes, as shown in FIG. 29, has an angle of repose of about  $35^{\circ}$  which is substantially the angle of the tilt frame 14 undergoes during unloading of the coke C. The cap 101 is spaced above and centered with respect to the tubes 103 via a series of centering studs 107 rigidly attached to the exterior of the tubes 103. The cap 101 rests on the studs 107 to create a space between the top of the tube 103 and the cap 101. The sand seal permits the gasses within the receiving chamber 86 to escape while preventing the outside atmosphere from entering and igniting the hot coke C. It will be appreciated that particulate emission is minimized by passing the gasses through the sand S prior to releasing the gas to the atmosphere. Vacuum relief is also provided in the event the pressure drops below atmospheric. As shown in FIGS. 29 and 30, plate 109 is free to move downwardly against the force of spring 111, allowing air to enter through plate openings 113.

Once the carrier is in place at the coke oven, the main frame 16 is optionally secured to the coke bench guide rail G, and the coke box 10 door is accurately aligned with the coke oven O, either the cylinders 72 or the power driven roller 54 may be used to advance the coke box 10 to engage the coke

oven face F as shown in FIG. 15. Referring jointly to FIGS. 15 and 19, the coke box 10 is advanced until a pair of stop bars 106 located on either side of the coke box 10 contact the coke oven buckstays BS and oven seal plates 108 are urged into engagement with the oven face F by springs 110. A container funnel section 107 attached to the panels 88 substantially surrounds the opening at the coke box 10. The oven seal plates 108 also substantially surround the coke box 10 but without being rigidly attached to the coke box 10. Additionally, the oven seal plates 108 extend past the coke box 10 and funnel section 115 to engage the oven face F to create a relatively tight seal around the circumference of the coke box 10. The ends of the springs 110 butt against a perpendicular lip 112 at the rear of the oven seal plates 108. Seal plate retainers 115, are connected to the coke box 10 through notches 116 in the seal plates 108. The notches are sized to permit the required movement of the seal plates. It will be appreciated that this arrangement permits the seal plates 108 to seal against the coke oven face F by compensating for minor side-to-side or top-to-bottom misalignment of the coke box 10 relative to the coke oven 0. In addition, slits (not shown) may be provided in the funnel section 115 to minimize any bowing which might otherwise occur from thermal gradients.

Once the coke box 10 is sealed to the coke oven 0, the coke box door plate 120, shown in the closed position in FIG. 6, may be shifted to the open position (shown in phantom in FIG. 6) to permit the coke box 10 to be loaded with a coke charge C. As shown in FIG. 6 and FIGS. 15 through 18, the door plate 120 has an opening 124 conforming substantially

to the opening 126 of the coke box 10 and two horizontal slots 128 located at the top of the door plate 120. The door plate 120 is slidably disposed within a slot 122 in the forward portion of the coke box 10 so that when preparing to load a coke charge C into the coke box 10, a door shifting frame 130 slides the door plate 120 so that the plate opening 124 substantially aligns with the coke box opening 126 as shown in phantom in FIGS. 6 and 16. Once the plate opening 124 is aligned with the coke box opening 146, the ram R may pushed the coke cake C from the oven 0 into the coke box 10.

Upon the opening of the coke box door, the radiation from the glowing coke will heat the air in the coke box, causing it to expand. In addition as the coke enters, gas is displaced. It has been found that this expansion and displacement can result in a relatively high velocity countercurrent flow of gas past the entering coke. This gas which can contain pollutants can re-enter the furnace area and exit the furnace vents and/or ascension tubes. It can also create an undesirable "blow-torch"-like flame around the coke box/oven face seal. This phenomenon can be avoided by exhausting the air from the coke box at a rate substantially equal to the rate at which the air expands and is displaced. In the embodiment shown, this is accomplished through the use of a blower 318 mounted on the rear face of the coke box which expels air from the coke box. In the event it is considered necessary or desirable to scrub any particulates from the expelled air, this can be accomplished by ducting the expelled gas from the box into a water reservoir. A convenient reservoir would be the reservoir 158 which covers the bottom of the box. In Figs. 4 and 35, duct 320 is shown connecting the

outlet of the blower to the reservoir 158. By controlling the rate of removing gas from the box no significant pollutants will enter the water, and none will be discharged to the atmosphere.

After the coke box 10 is loaded, the shifting frame 130 slides into the door plate 120 to the closed position shown in FIGS. 6 and 16. An additional advantage is that the door plate 120, shown in phantom in FIG. 5, protects and shields the operator in the cab 36 from the heat released from the open coke oven 0.

The door shifting frame 130 engages the door plate 120 on each vertical side so that the door plate 120 slides with the shifting frame 130. To maintain the alignment between the coke box 10 and the door plate 120, upper guides 132 rigidly secured to the coke box 10, are projected into the two horizontal slots 128 located at the top of the door plate 120 as shown in FIG. 6. A pair of actuators 134, rigidly attached to the top and the bottom of the tilt frame 14, connect the tilt frame 14 with the door shifting frame 130 to control the movement of the door plate 120. Alignment between the door shifting frame 130 and the tilt frame 14 is maintained with a series of guide rollers 136 carried by the door shifting frame 130. The tilt frame 14 is interposed between the rollers 136 so that the shifting frame 130 may open and close the door plate 120, while maintaining alignment with the tilt frame 14.

To accommodate movement of the coke box 10 along the inner frame 50, the coke box 10 may be opened and closed in two positions. As may best be appreciated in FIG. 15, the door shifting frame 130 has a forward portion 130F which is shown engaging the door plate

120 and a rear portion 130R which may also engage the door plate 120 (not shown) if the coke box 10 were positioned further to the rear of the tilt frame 14.

In order to control the temperature of the door, the door plate 120 is hollow to permit water to be pumped through an upper water inlet 138 and cascade past a series of baffles 140, illustrated in FIGS. 17 and 18, until the water leaves through a lower water outlet 142. A hose, not shown, empties the water back into the lower water collection through 158. In addition, water may be pumped through one or more of vertical channels 143 and 144 surrounding the door plate 120 to assist in conducting heat away from the door plate 120. Once the door is closed, it also may be clamped against the vertical channels 143 to more completely seal the coke in the box until the completion of the cooling, discussed below.

In accordance with an important aspect of the invention, a system to indirectly cool the hot coke C to below its kindling temperature is shown in FIGS. 22 and 23. The initial cooling of the coke receiving chamber 86 begins while the coke box 10 is in position at the coke oven 0 through a cooling water system. Later, the coke box 10 may be cooled either on the carrier vehicle or taken to a remote cooling station. The basic cooling system comprises a pump 146 to distribute water from a catch basin 148 in the main frame 14 or the cooling station to an upper trough 150 on the coke box 10 which cascades water along exterior of the receiving chamber 86 of the coke box 10.

Referring again to FIG. 1, a pump 146, located on the main frame 16, pumps water from a catch basin 148 through a standpipe 152, to an upper reservoir 154 centrally located at the top of the coke box

10. A plurality of weir tubes 156 best shown in FIG. 23 maintain the correct level within the reservoir 154 by conducting any water overflow to a lower collection trough 158 extending substantially around the bottom of the coke box 10. The water, pumped into the upper reservoir 154, distributed to an upper trough 150, extending substantially around the entire length of the coke box 10.

As illustrated in FIGS. 22 through 26, the upper trough 150 is formed by a top plate 160, side plates 162 surrounding the upper portion of the coke box 10, and a rigid bottom plate 164. Water enters the water trough 150 from the upper water reservoir 154 through a plurality of inlets 166. The bottom plate 164 is rigidly secured to the support posts 90 as best shown in FIG. 24. Rigidly connected to the bottom plate by a plurality of bolts 168 is a flexible arcuate-shaped plate 170, extending the entire length of the coke box 10, creating a dam with the receiving chamber panels 88. In the embodiment shown the dam plate 170 has a plurality of dimples 172 intermittently spaced along the dam plate 170 engaging, but not connecting, the receiving chamber panels 88 to create a very small water gap 174. The same result can be achieved by installing spacers, for example, segments of wire or rod of the desired diameter, between the dam plate and the surface of the panels 88. The water gap 174 permits the water from the upper trough 150 to cascade over the receiving chamber panels 88, thereby cooling the coke box 10. The dam plate 170 is made of a thin, resilient material preloaded against the panels 88 so that it can flex with the panels 88 to maintain a consistent water gap 174 regardless of the deflection of the panels 88.



The water cascades down the side of the chamber panels 88 thus indirectly cooling the hot coke. As shown in FIGS. 22 and 23, the water is collected in a relatively U-shaped lower collection trough 158 which surrounds the bottom of the coke box 10. Water from the lower trough 158 may be drained into the catch basin 148 in the main frame 16 through a pair of gate valves 176 located on either side of the coke box 10. The water level in the lower trough 158 is maintained by a system of wiers 178 located directly above the gate valves 176. As shown in FIG. 31, the wiers 178 have relatively small drain holes 180 which, during operation of the pump 146 have little effect, but which allow virtually complete draining of the reservoir 136 when the pump 146 is shut down.

As shown in FIGS. 30 through 34, each gate valve 176 comprises a slidably mounted valve plate 182 having an opening 184 conforming substantially to the valve opening 186 so that the water is drained from the lower collection trough 58 by aligning the plate opening 184 with the valve opening 186. A valve seal 188 which surrounds the valve opening 184 is shown in FIG. 34. A system, not shown, is provided to assure the gate valves 176 are open when the coke box 10 is in a predetermined orientation on the vehicle 12. Activators, not shown, may also be provided to selectively open the gate valves as when the coke box 10 is removed from the vehicle 12.

The coke box 10 may be cooled to a desired temperature directly on the carrier vehicle 12 or it may be taken to a cooling station (not shown) where it may be unloaded from the carrier vehicle 12 to finish the cooling process, permitting the carrier vehicle 12 to obtain an empty coke box 10 and return to the coke oven 0 to continue unloading the

coke C. It is contemplated that the carrier vehicle 12 approaches a series of cooling racks to substantially align the coke box 10 with a cooling rack in a manner similar to the coke oven 0. Once the coke box 10 is substantially aligned, the actuators 52 fine-tune the lateral alignment. The telescoping cylinders 74 or the power rollers 54 move the coke box 10 off the carrier vehicle into the cooling rack. The coke box 10 is then cooled by cascading water over the exterior of the coke box 10. Alternatively, or in addition, the coke C may be cooled using an inert gas cooling system such as is discussed below.

It is contemplated that the cooling station will comprise a plurality of cooling racks, each cooling rack able to hold a coke box 10 during the cooling process. The water distribution system is similar to the system contained in the carrier vehicle 12. Water is pumped from a catch basin 148 located at the bottom of the cooling racks to the upper water reservoir 154 of the coke box 10. In a manner similar to the cooling process discussed for the carrier vehicle 12, the water cascades over the exterior of the coke box 10, thus cooling the hot coke C.

It may be desirable to introduce mixing and movement of the atmosphere within the coke box to supplement any convection currents which might otherwise be established. Such circulation can be accomplished by employing, for example, a blower within coke box. Alternatively, the atmosphere might be circulated using a circulation system of the general nature in FIGS. 36-40 shown and described below in the context of heat dissipation through circulation of inert gas. It is expected that such a

blower or circulation system will increase the rate of heat transfer to and through the sidewalls of the coke box, as when using the water cascade system described above. Such a blower system can be coupled with a system of baffles discussed below in connection with the inert gas circulating system.

It may also be desirable to increase the gas circulation between the side walls of the coke box and the coke cake. One way to accomplish this is by forming horizontally extending corrugations in the side panels 88 of the coke box 10. Such corrugations are depicted in phantom as items 89 in FIG. 22. It is contemplated that the innermost surfaces 89a of the corrugations 89 provide lateral support for the coke cake, with the outer portions of the corrugations forming "ducts" 89b through which circulating gas can travel.

Once the coke C is cooled, a carrier vehicle 12 may take the cooled coke box 10 to an area for discharge, such as a coke sizing station where the coke cake C may be sized into the required pieces. It is contemplated that the carrier vehicle 12 approach the coke crushing station to substantially align the coke box 10 with the coke crushing station in a manner similar to the coke oven 0 and the cooling racks. Once the coke box 10 is substantially aligned, the inner frame actuators 52 find tune the lateral alignment. The telescoping cylinders 74 shift the coke box 10 along the inner frame 50 to the desired position and thereafter secure the coke box 10 to the tilt frame 14. A pair of tilt actuators 190, pivotally connecting the tilt frame 14 and the main frame 16 on either side of the carrier vehicle 12, raises the tilt frame 14 about the pivot shaft. FIG. 35 illustrates a carrier vehicle 12 in a tilted

(dumping) position with the coke box 10 inclined at a sufficient angle to cause the coke cake C to slide out of the coke box 10. With such an arrangement the cooled coke may be smoothly discharged, without subjecting the coke C to an uncontrolled free fall which might pulverize it, and without releasing contaminants to the atmosphere. Alternatively, or in addition, removal of the coke may be aided by vibrating the box. Such vibration may be effected by mounting a vibrator 322 on one of the box surfaces as illustrated in FIG. 35.

Removal of any coke that might not freely slide out of the coke box when tipped may also be accomplished through the use of a scraper at the dump station. Such a scraper arrangement is illustrated in FIG. 35, where a scraper blade 324 is shown mounted to a beam 326. This beam slides through a guide 328 pivoted at point 330 in the dump chute to accommodate movement of the scraper up the inclined surface of the coke box 10. With the coke box in place and all coke removed except any which might stick and remain behind, the scraper blade can be moved into the box along the floor thereof to loosen any coke which has not previously fallen out.

In accordance with another aspect of the invention, provision may be made for an inert gas cooling system, such as the one depicted in FIGS. 36 through 40. Like the water cooling system, the inert gas cooling system may be carried directly on the carrier vehicle for immediate cooling or it may be stationed at a remote cooling station.

In the embodiment shown (FIGS. 36 and 37), the inert gas cooling system is attached to the tilt frame 14 so that the coke box 10 may roll along the inner frame 50 without interference. More

specifically, a pair of sealing tube structures 200 are attached to the top off the tilt frame 14 so that the coke box 10 may pass underneath without interference. Similarly, a vortex separator 202 and a series of finned heat dissipation tubes 204 are attached to the top and side of the tilt frame 14, respectively, so as not to interfere with the movement of the coke box 10.

After the coke box 10 is loaded with hot coke C and the coke box 10 is secured within the tilt frame 14 as previously discussed, the sealing tube structures 200 shown may be positioned over a rear supply vent 206 and a front return vent 208, respectively. The sealing tube 200, shown in the raised position in FIG. 37, is positioned by an upper support arm 210 and a lower support arm 212 to drop into a sand reservoir 105, thus, sealing the rear supply vent 206 and front return vent 208 and creating a closed passage between the heat dissipation tubes 204 and the coke box 10. An actuator 214 pivotally connected to the top of the tilt frame 14 and to the upper support arm 210 controls the positioning of the sealing tube 200. Once a closed passage is created, a blower 216 attached to the tilt frame 14 between the rear supply vent 206 and the heat dissipation tubes 204, draws the cooling gas through a tubular supply duct 218 connecting the heat dissipation tubes 204 with the rear supply vent 206. To ensure that the cooling gas enters the coke box 10 and circulates among the hot coke C, a baffle plate 102, located between the rear supply vent 206 and the coke C, maintains an open duct 104 by preventing the coke C from clogging the rear supply vent 206. The plate 102 may have spaced holes or nozzles (not shown) to distribute the gas

flow (see the arrows in Fig. 4). As suggested above, this baffle and nozzle arrangement can also be employed with indirect cooling for internal gas circulation.

One or more additional baffles, depicted as items 103 in FIGS. 2, 4 and 35 may be employed to prevent the short-circuiting of the gas between the supply vent 206 and the return vent 208. In order to accommodate variations in the height of the charge of coke, the baffles may be in the form of loosely hanging plates of sufficient length to reach the lowest contemplated coke charge. With higher coke charges, the plates will simply deflect rearward, still accomplishing their intended purpose of preventing the short-circuiting of the gas.

The cooling gas may be any gas which will serve to lower the temperature of the coke C without interacting chemically with the coke C, such as nitrogen ( $N_2$ ) and carbon dioxide ( $CO_2$ ). One method of introducing carbon dioxide ( $CO_2$ ) into the system is by placing dry ice in the closed coke box and/or cooling system, whereupon the ( $CO_2$ ) released displaces any air present therein.

The blower 216 forces the cooling gas to circulate within the coke box 10 and to exit at the front return vent 208. After hot gas exits the coke box 10 through the front return vent 208, it travels through a tubular return duct 220 to a vortex separator 202 rigidly attached to the top of the tilt frame 14. The vortex separator 202, is located between the front vent 208 and the heat dissipation tubes 204, such that it does not interfere with the movement of the coke box 10 along the inner frame 50. The vortex separator 202 removes particulate matter from the hot gas before passing clean gas

through a second return duct 222 to a series of heat dissipation tubes 204. The dirty particulate matter is collected at the bottom of the vortex separator 220 for later removal.

In the embodiment shown, a plurality of heat dissipation tubes 204 are attached along the side of the tilt frame 14 by means of side assemblies 224. Referring to FIGS. 39 and 40, the side assemblies 224 are attached to the tilt frame 14 to support the heat dissipation tubes 204. As cooling gas is needed, the blower 216 draws gas from the tubes 204 and circulates the gas through the coke box 10. When the cooling process is finished, the actuators 214 raise the sealing tube structures 200 so that the coke box 10 may be removed.

Referring to FIG. 38, the upper support arm 210 and the lower support arm 212 are pivotally connected to the circular sealing tube 200 by pins 228 and 230, respectively, located on either side of the sealing tube 200. When the sealing tube 200 is in the lowered position as shown in FIG. 38, the sand S forms a seal and a closed passage between the receiving chamber 86 and the heat dissipation tubes 204 is formed.

The front vent 208 comprises a substantially circular inner tube 232 creating a passage into the receiving chamber 86 and an outer tubular sand reservoir 234 surrounding the inner tube 232. The sealing tube 200 is also substantially tubular to fit between the inner tube 232 and outer sand reservoir 234.

The means for opening the tube 232 to permit the cooling gas to enter and leave the receiving chamber comprises a bar 236 rigidly attached to the interior wall 238 of the sealing tube 200 and a plate 240

pivotally mounted on a pin 242 in the center of the tube 232 such that the bar 236 pushes one end of the plate 240 as the sealing tube 200 is lowered over the tube 232. A weight 244 connected to the other end of the plate 240 forces the plate 240 to close the tube when the sealing tube 200 is raised.

The means for closing the passage to the return duct 220 when the sealing tube 200 is in the raised position comprises an oval plate 246 pivotally mounted on the pin 248 in the center of the return duct 220, and a lever 250 attached to the oval plate 246 such that the plate 246 opens the passage when the lever 250 is lifted and closes the passage when the lever 250 is lowered.

When the sealing tube 200 is lowered over one of the vents, the lever 250 engages the inner tube 232 of the vent 208, forcing the lever 250 to rise and, concomitantly, forcing the plate 246 to open. As the plate 246 opens, cooling gas is permitted to enter the coke box 10. Similarly, when the sealing tube 200 is lifted off the vent 208, the lever 250 falls, causing the plate 246 to close, shutting off the supply of cooling gas to the coke box 10. The oval plate had a truncated outside edge which substantially seals the tube 200 in the closed position.

It will be appreciated that the cooling system shown dissipates the heat from the coke into the atmosphere via fins 252 surrounding the cooling tubes 204. Alternatively, the heat may be recovered for other uses, as, for example, preheating the coking coal, through the use of a heat exchanging arrangement in lieu of the cooling tubes 204.



We claim as our invention:

1. A carrier vehicle for transporting and maneuvering a coke box for receiving and carrying a coke charge from a coke oven in a pollution-free manner, comprising, in combination,

a rear self-propelled wheel assembly and a forward wheel assembly connected to a lower main frame, the rear wheel assembly being articulated to said main frame to facilitate the maneuvering of the vehicle, the wheels of the forward wheel assembly also being steerable to facilitate the maneuvering of the vehicle,

an upper tilt frame pivotally connected to the lower main frame by a forward pivot shaft for supporting a coke box,

the tilt frame having a means for maneuvering a coke box for receiving and delivering coke,

means for preventing relative movement between a coke box and a coke oven while loading coke into the coke box,

means for inclining the tilt frame for unloading coke from a coke box,

means for circulating water from a lower catch basin in the main frame to the top of a coke box.

2. A carrier vehicle according to claim 1 wherein the means for preventing relative movement comprises means for clamping the main frame to a coke bench guide rail.

3. A carrier vehicle according to claim 1 wherein the means for maneuvering a coke box comprises a pair of telescoping cylinders attached between either side of the tilt frame and the coke box and to position a coke box along the tilt frame.

4. A carrier vehicle according to claim 1 wherein the means for maneuvering a coke box comprises means for rolling a coke box relative to the tilt frame and to engage a coke oven for loading a coke charge into a coke box.

5. A carrier vehicle according to claim 1 wherein the means for maneuvering a coke box comprises means for laterally shifting the tilt frame relative to the main frame to align a coke box with a coke oven.

6. The carrier vehicle according to claim 5 further comprising probe means to detect lateral misalignment between the tilt frame and the oven and means to actuate the means for laterally shifting the tilt frame to correct the misalignment.

7. A carrier vehicle according to claim 1 wherein the means for circulating water comprises a pump for transporting water from a basin in the lower main frame which collects water to the top of a coke box.

8. A coke box for dry quenching a charge of coke transported by a carrier vehicle comprising, in combination

a receiving chamber formed of metal panels having an interior shape and a volume substantially equal to that of a charge of coke,

door means,

means for cooling the surfaces of the receiving chamber to indirectly cool the charge of coke by cascading water from an upper reservoir at the top of the coke box, over the exterior of the panels, and into a lower reservoir,

means for supporting the panels without rigid interconnection therewith,

means for creating an effective seal between the coke oven and the receiving chamber to prevent particulate matter from escaping,

and means for circulating gas within the chamber to enhance the transfer of heat from the coke to the panels of the receiving chamber.

9. A coke box according to claim 8 wherein the interior of the receiving chamber comprises baffle means to direct the flow of gas over the coke.

10. A coke box according to claim 8 wherein the upper reservoir distributes water to an upper trough formed by means comprising a resilient strip extending the length of the coke box adjacent the panels of the receiving chamber and spacer means interposed between the inner surface of the strip and the panels of the receiving chamber to create a plurality of small water gaps, the water gaps permitting water to cascade over the panels and into a lower collection trough.

11. A coke box according to claim 10 wherein the strip can flex with the panels to maintain a consistent water gap regardless of any deflection of the panels.

12. A coke box according to claim 8 which further comprises means for expelling gas from the receiving chamber as it is heated and displaced by the entering coke.

13. The coke box according to claim 12 wherein the means for expelling the gas comprises a blower, the coke box further comprising duct means connecting the exhaust of the blower to means for scrubbing pollutants from the gas.

14. A coke box according to claim 8 wherein the sealing means comprises an oven seal extending the circumference of the receiving chamber, and springs connected to the coke box for urging the sealing means against the oven face.

15. A coke box according to claim 8 wherein at least a portion of the side panels of the receiving chamber have horizontal corrugations formed therein to support the coke while permitting the flow of gas past the coke.

16. A coke box according to claim 8 further comprising means for controlling pressure differentials within the coke box, said means comprising means for releasing excess pressure from the coke box and means for compensating for subatmospheric pressures which may be generated within the coke box.

17. A coke box according to claim 8 wherein the door comprises an internal chamber to permit water to flow through the interior of the door to maintain the door within acceptable temperature limits.

18. A coke handling and quenching apparatus comprising, in combination,  
a coke box having an interior shape and a volume substantially equal to that of a charge of coke for receiving and carrying a coke charge from a coke oven in a pollution-free manner, and  
a self-propelled carrier vehicle for transporting and maneuvering the coke box, comprising, in combination,  
an upper tilt frame for supporting the coke box pivotally connected to a lower main frame, the tilt frame having a means for maneuvering the coke box for receiving and delivering the coke charge,  
means for preventing relative movement between the coke box and the coke oven face during loading of a coke charge, and  
means for inclining the tilt frame for unloading the coke charge from the coke box.

19. The apparatus according to claim 18 further comprising cooling means comprising heat dissipation means external to the coke box, duct means connecting the coke box and the heat dissipation means, and means for circulating inert gas through the coke box, the duct means and the heat dissipation means.

20. The apparatus of claim 19 further comprising a vortex separator located within the duct means to remove particulate matter from the inert gas.

21. The apparatus of claim 19 wherein the heat dissipation means comprises heat recovery means to reclaim at least a portion of the heat being dissipated.

22. A method for dry quenching a charge of coke from a horizontal discharge coke oven comprising:

- (a) aligning the open end of a coke box integrally closed on five sides and open on one end and having a cross section, volume and surface area substantially equal to that of the charge of coke with the discharge end of the coke oven;
- (b) creating an effective seal between the coke oven face and the coke box to minimize the escape of coke and air contaminants during the coke discharging operation;
- (c) pushing the charge of coke horizontally from within the coke oven directly into the coke box through the open end while maintaining the coke in a form with substantially the same cross section and

surface area as it had within the coke oven;

- (d) enclosing the coke within the coke box while the coke box is in position at the discharge end of the coke oven by closing the open end of the box to substantially isolate the coke from atmospheric oxygen and external cooling media;
- (e) indirectly cooling the coke within the coke box to below its kindling temperature by passing water over the exterior surfaces of the coke box while mechanically circulating the gas within the box;
- (f) removing the coke box and coke to a coke discharging area; and
- (g) discharging the cooled coke from the coke box by re-opening the end of the coke box and inclining the coke box to cause the coke to slide out the open end.

23. Method of claim 22 further comprising assisting in the removal of coke from the coke box by mechanically vibrating one or more of the box surfaces.

24. Method of claim 22 further comprising assisting in the removal of coke from the coke box by scraping any remaining coke therefrom.





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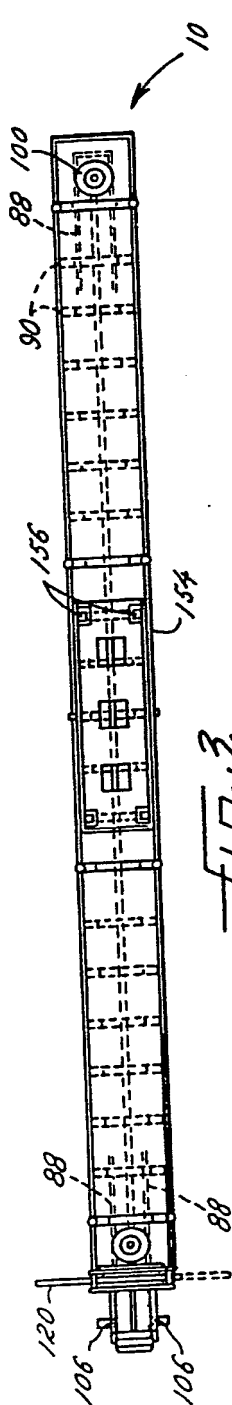


FIG. 3.

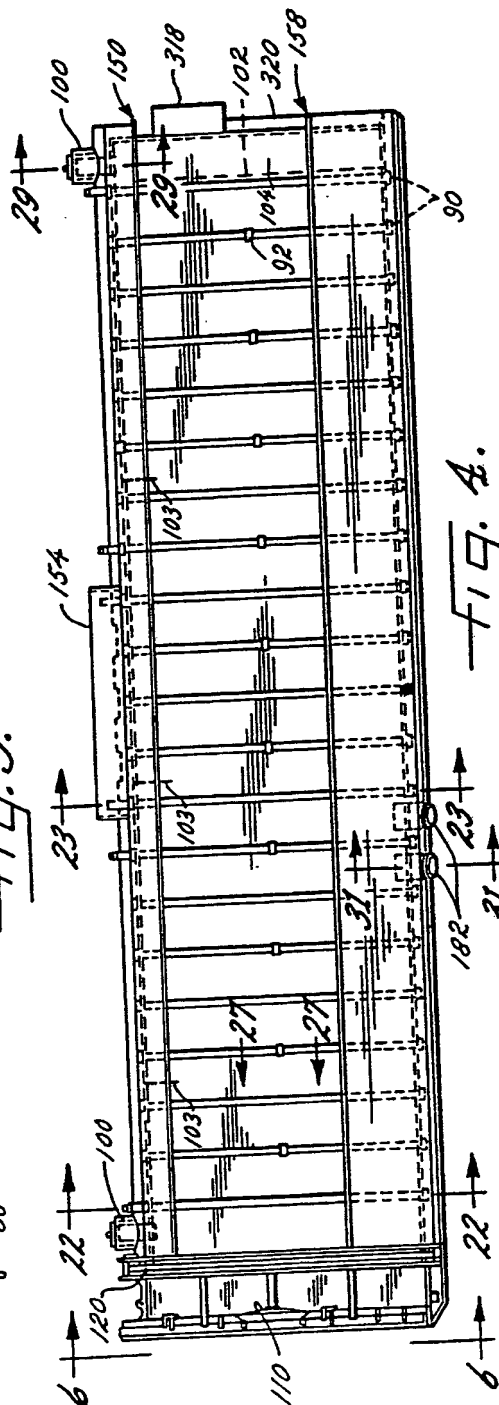


FIG. 4.

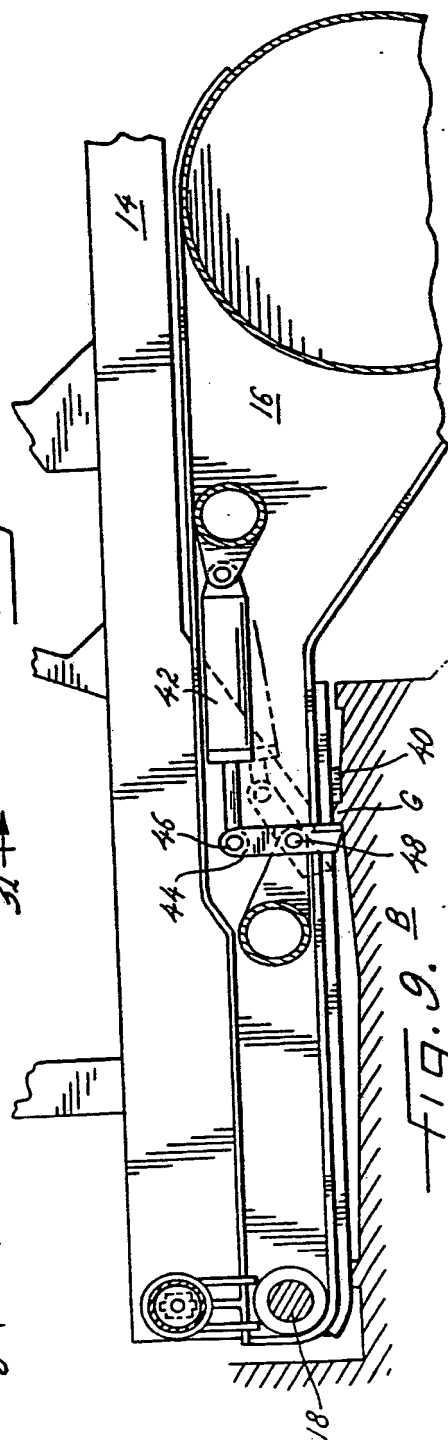
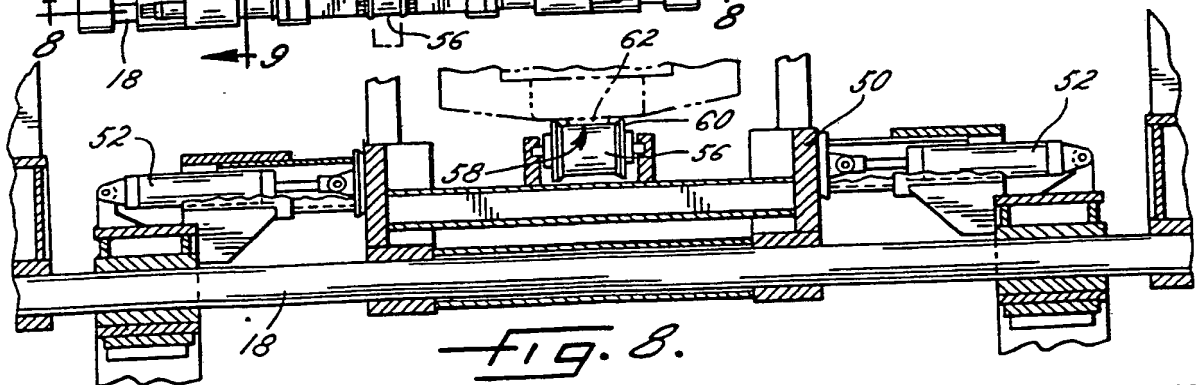
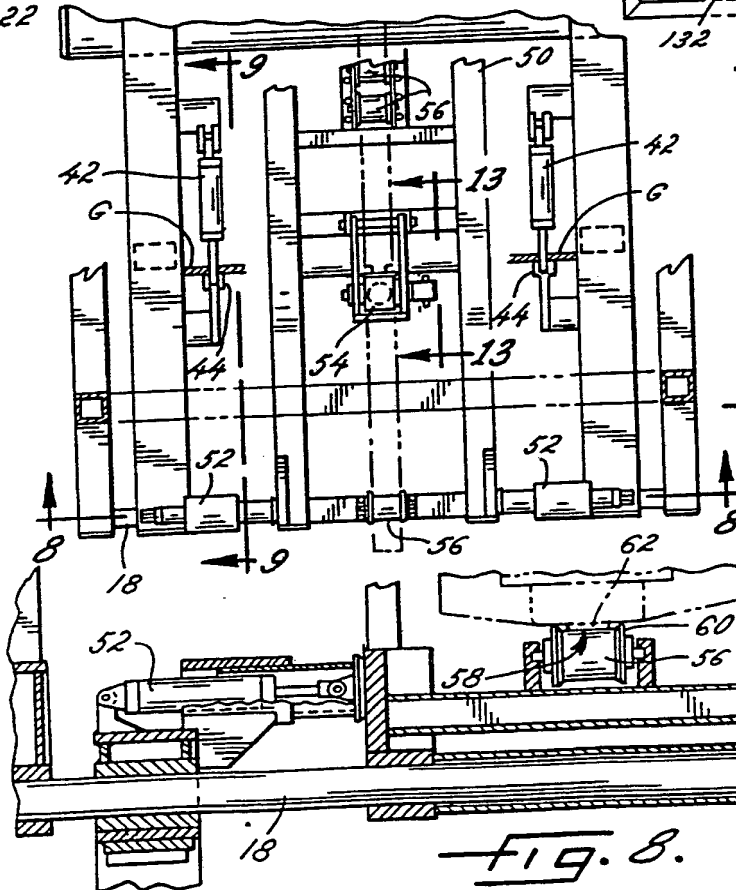
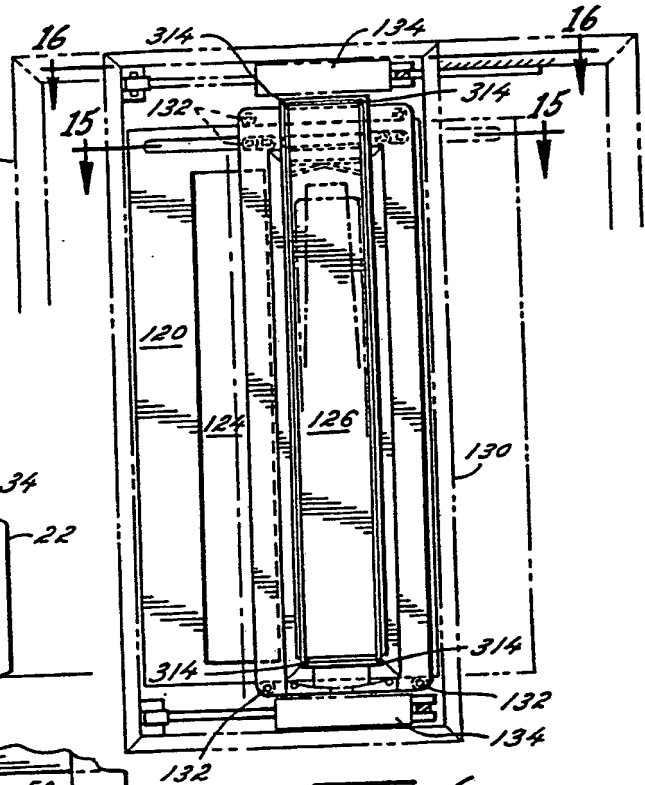
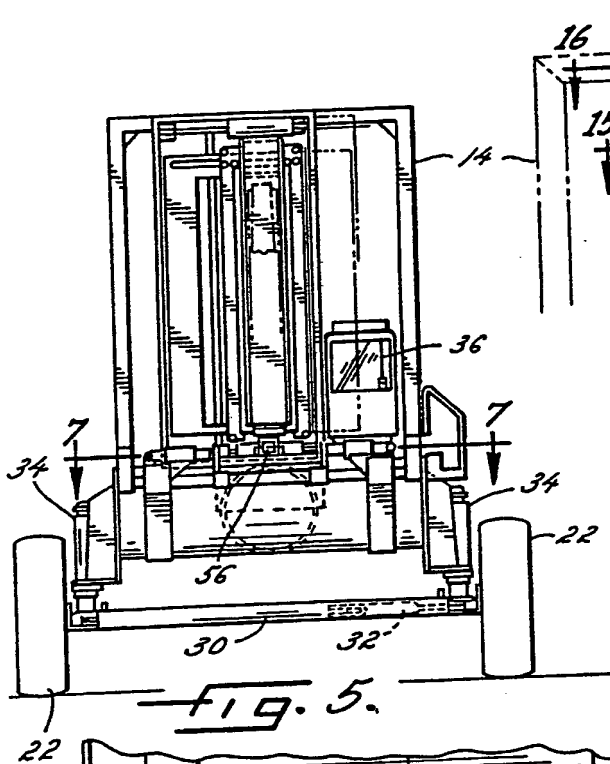


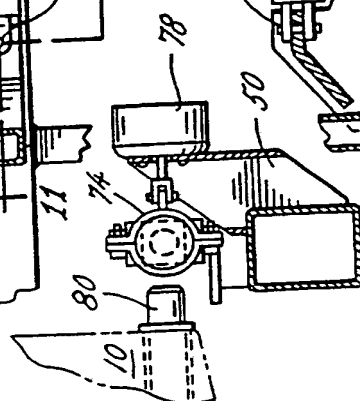
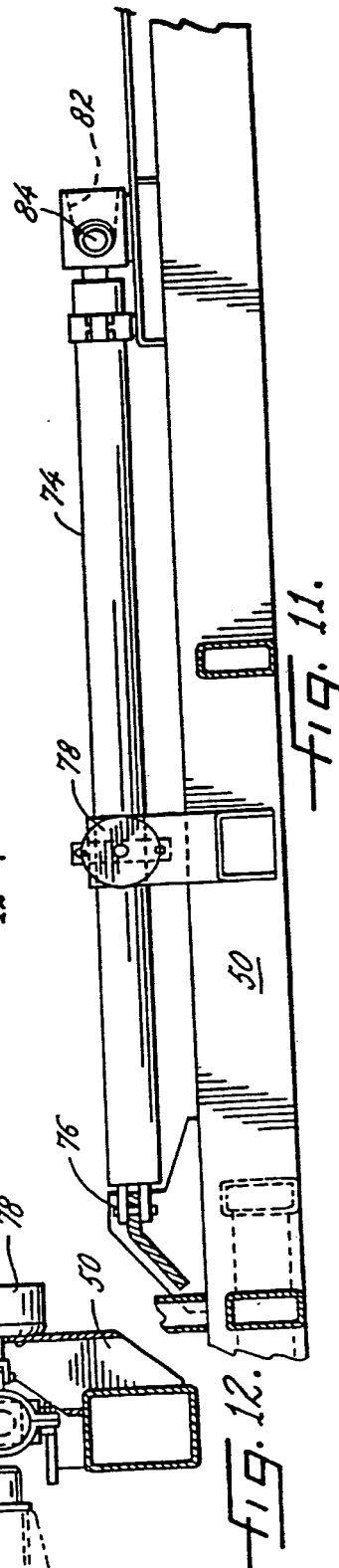
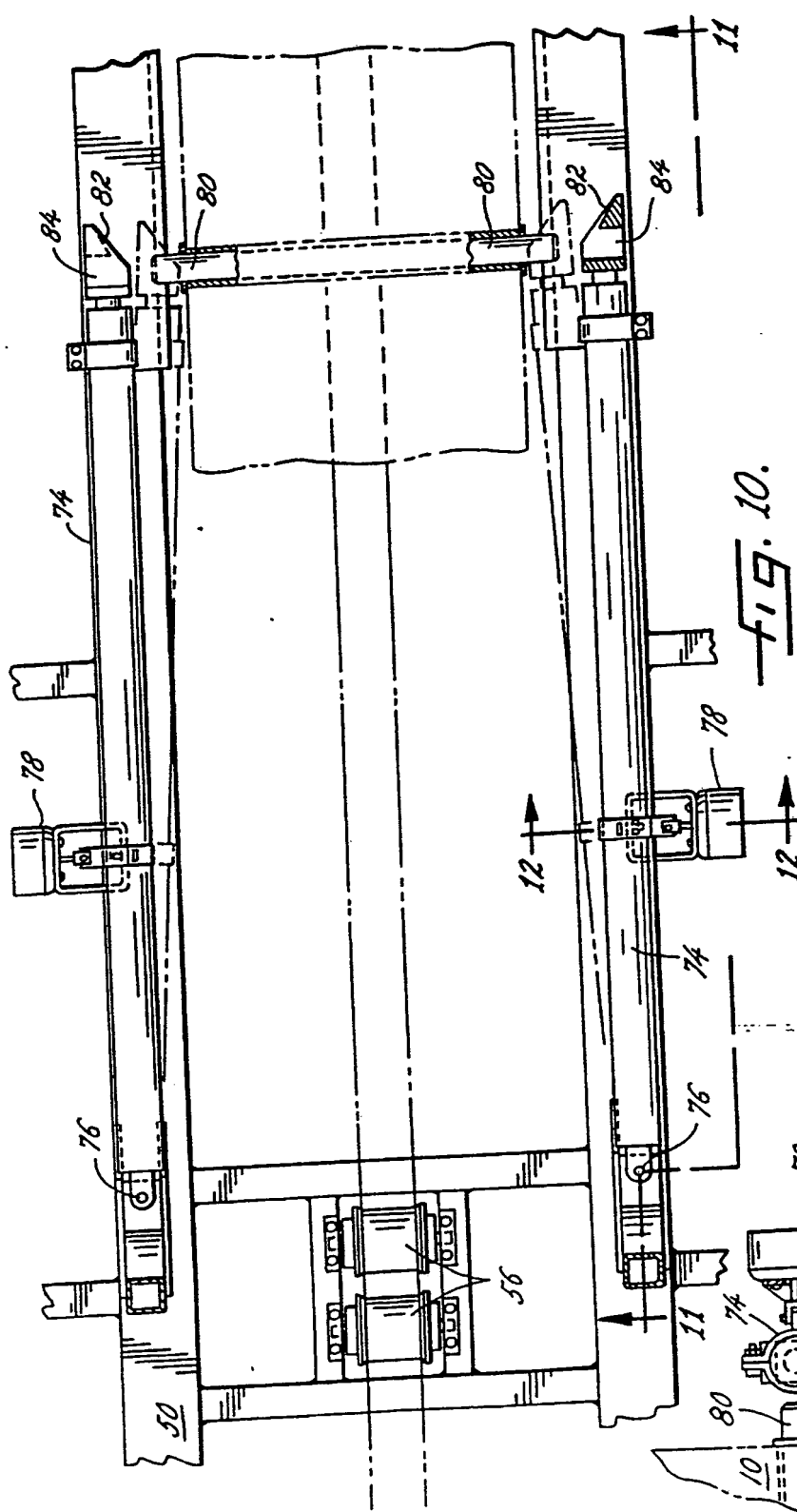
FIG. 9.

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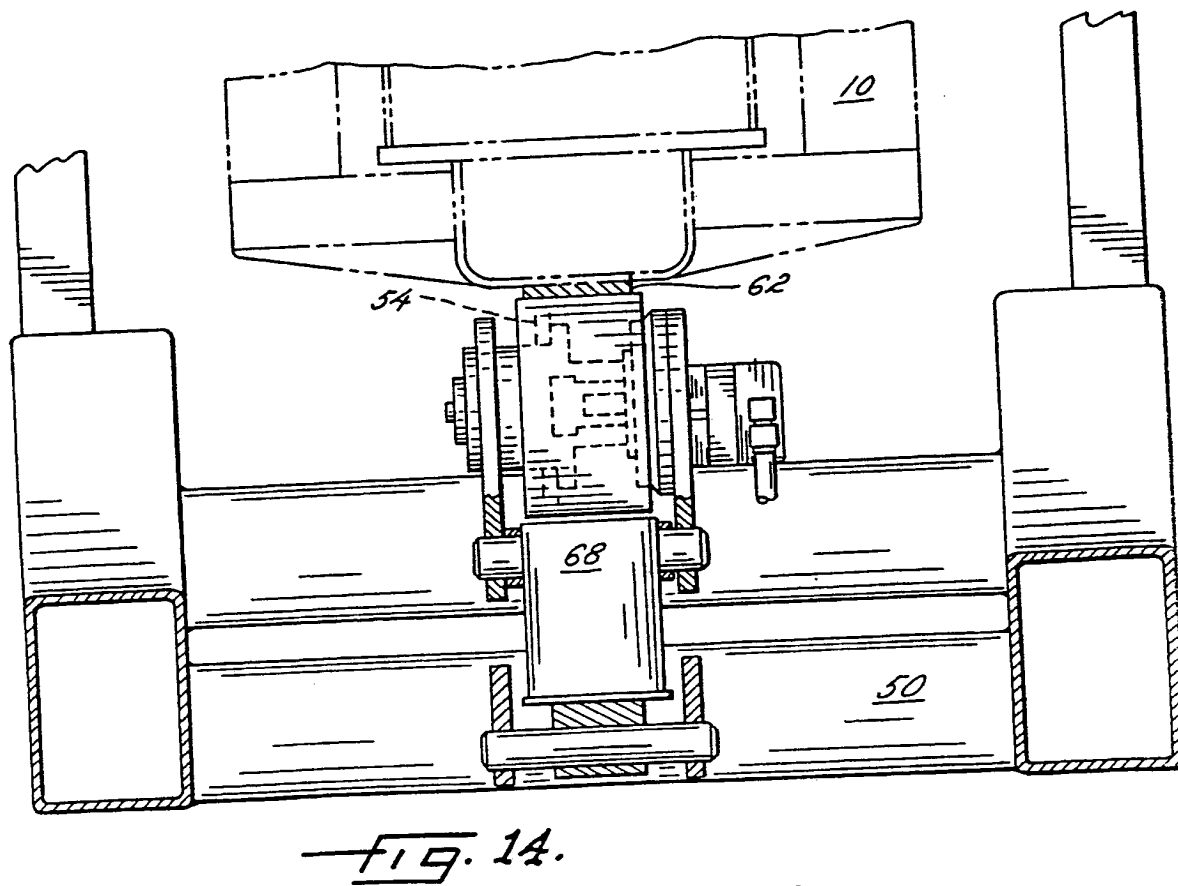
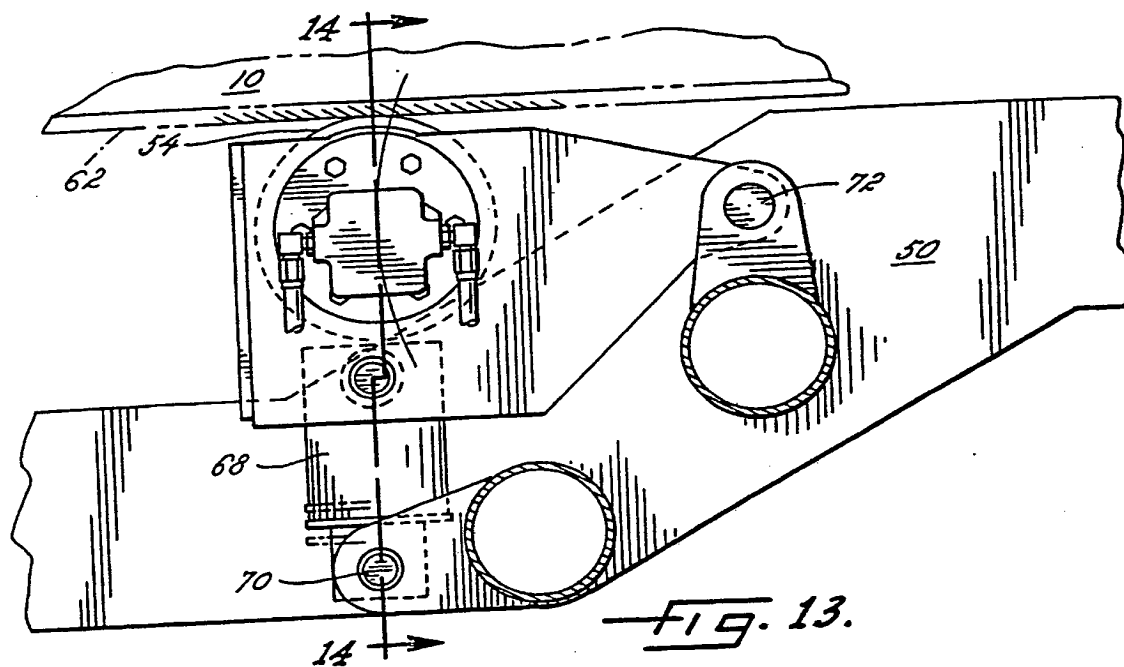
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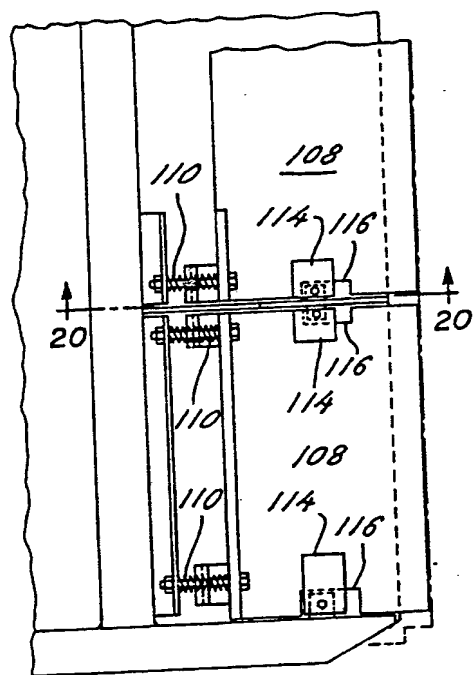


FIG. 19

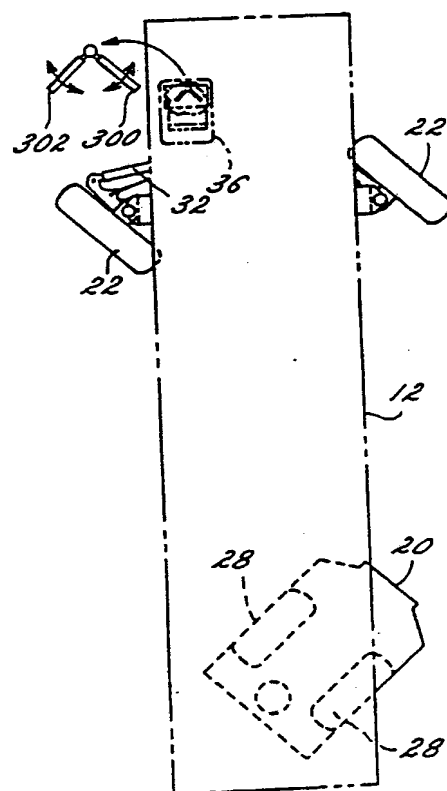


FIG. 21

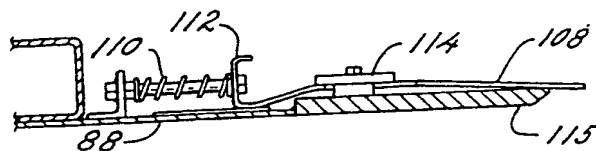


FIG. 20

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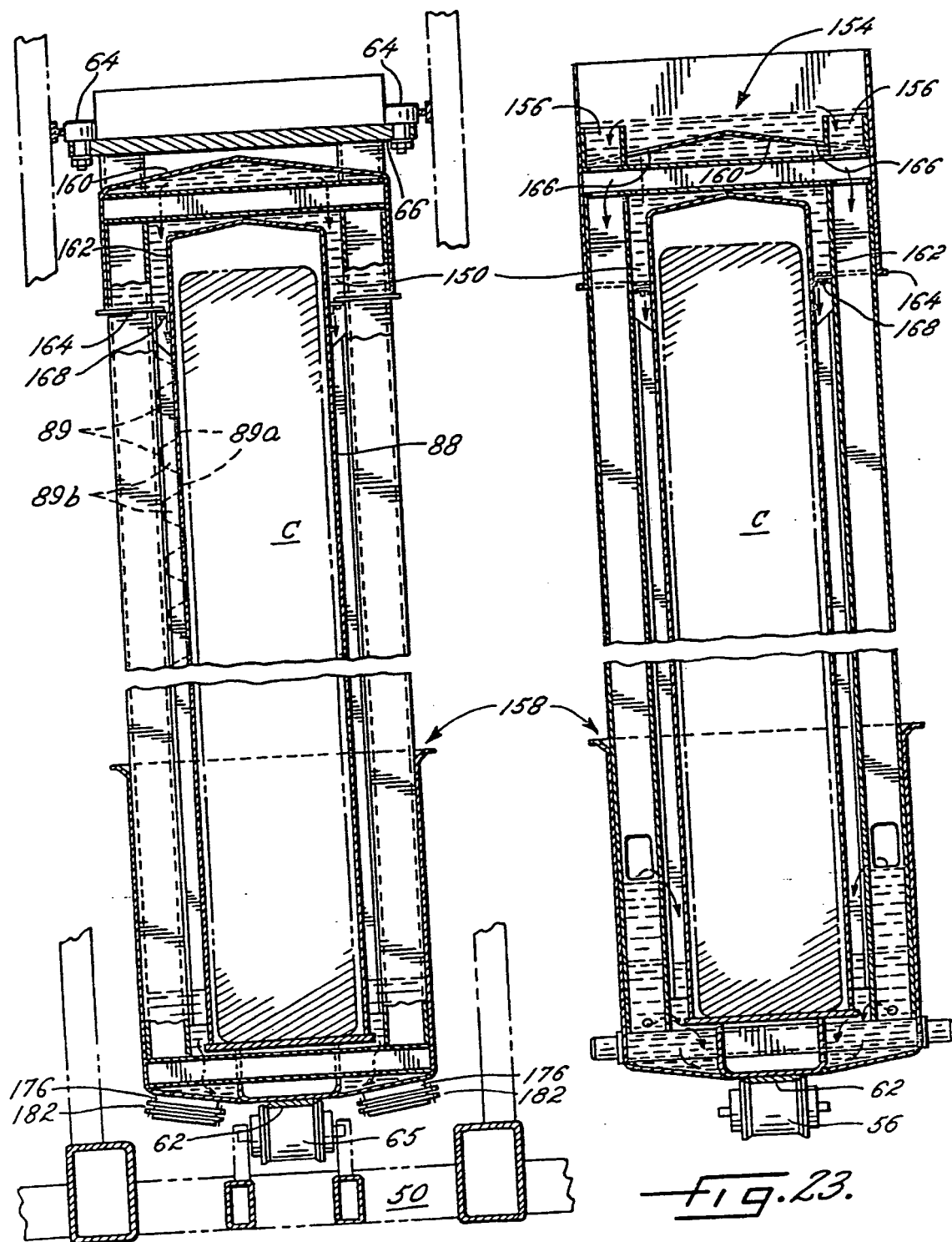


Fig. 22.

Fig. 23.

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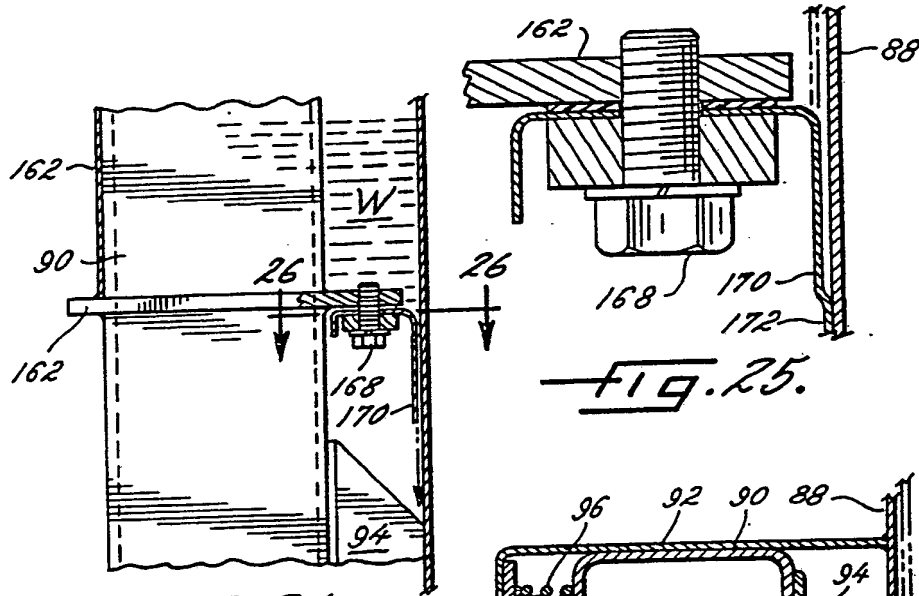


FIG. 25.

FIG. 24.

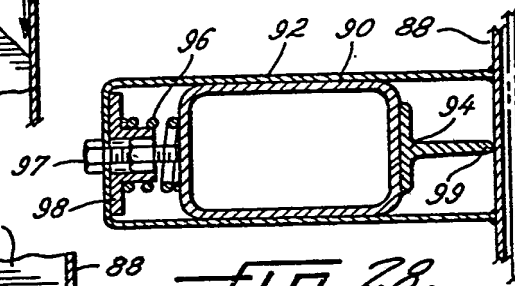


FIG. 26.

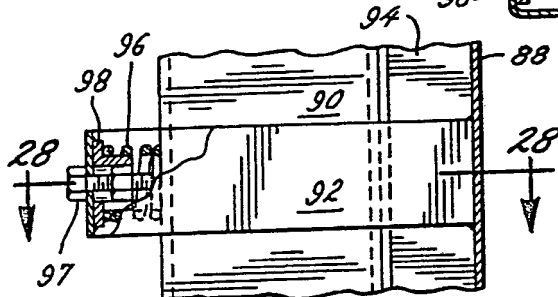


FIG. 27.

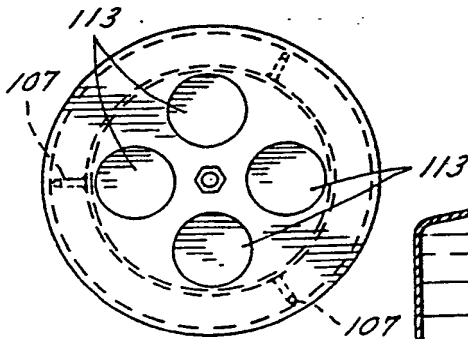


FIG. 28.

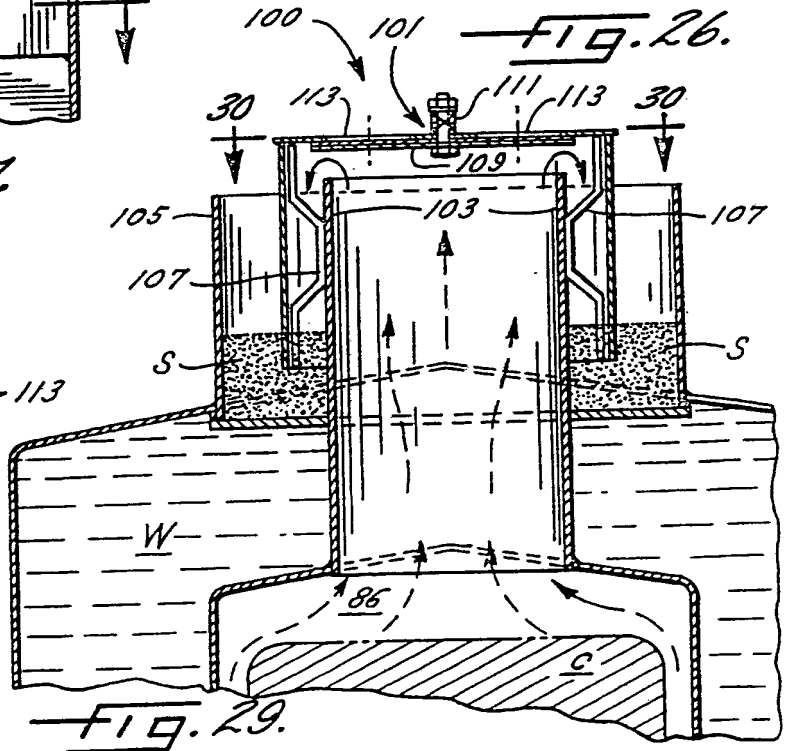


FIG. 29.

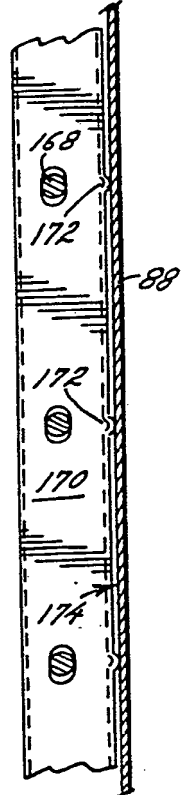
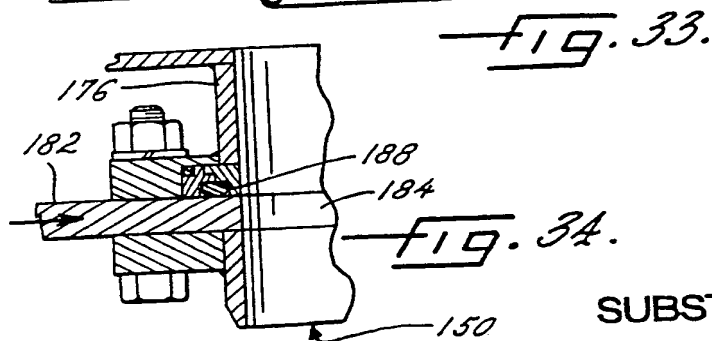
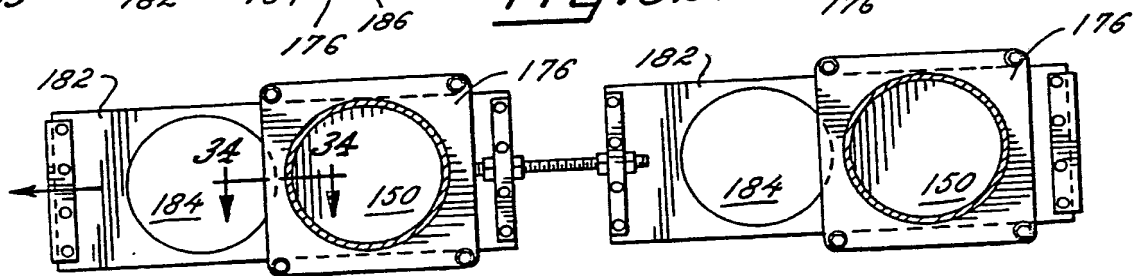
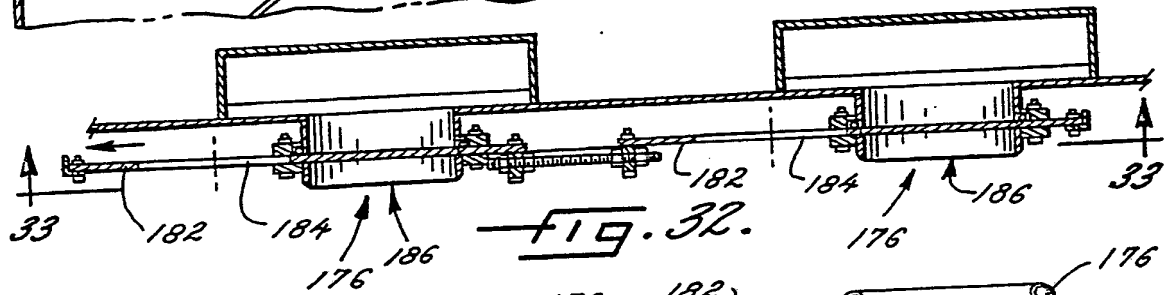
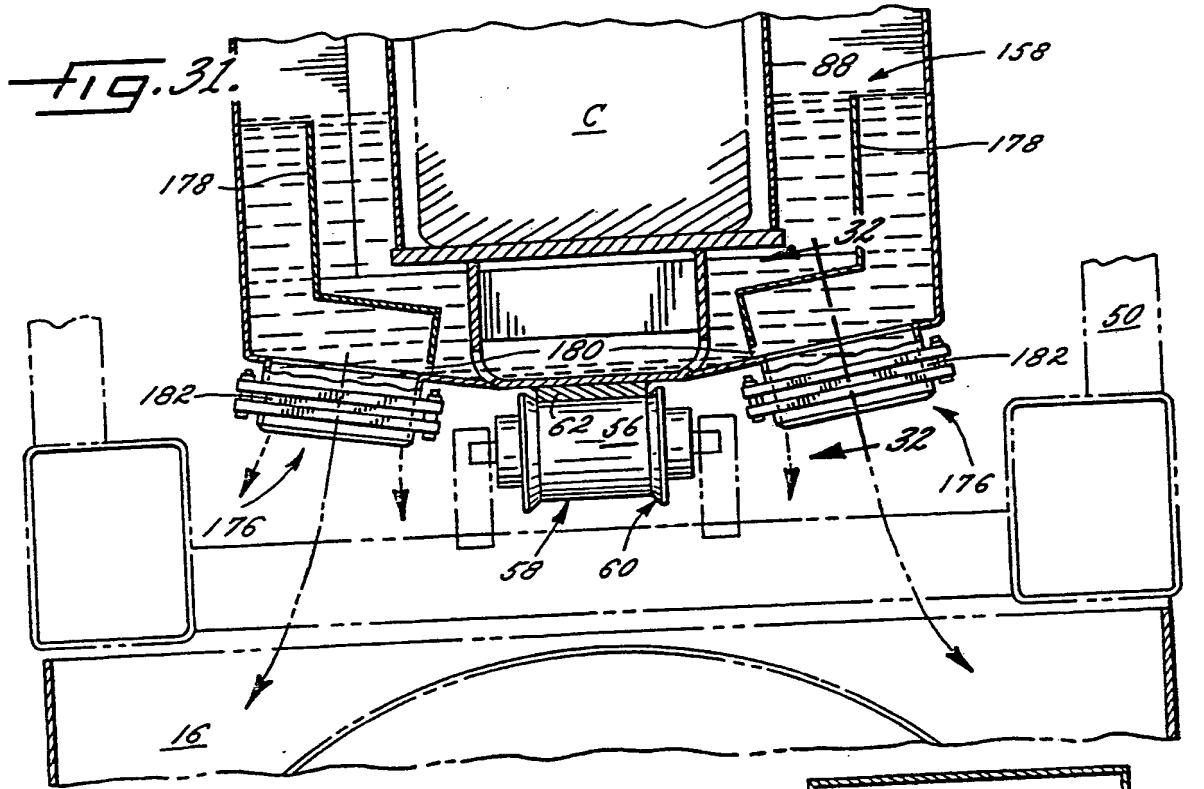


FIG. 30.

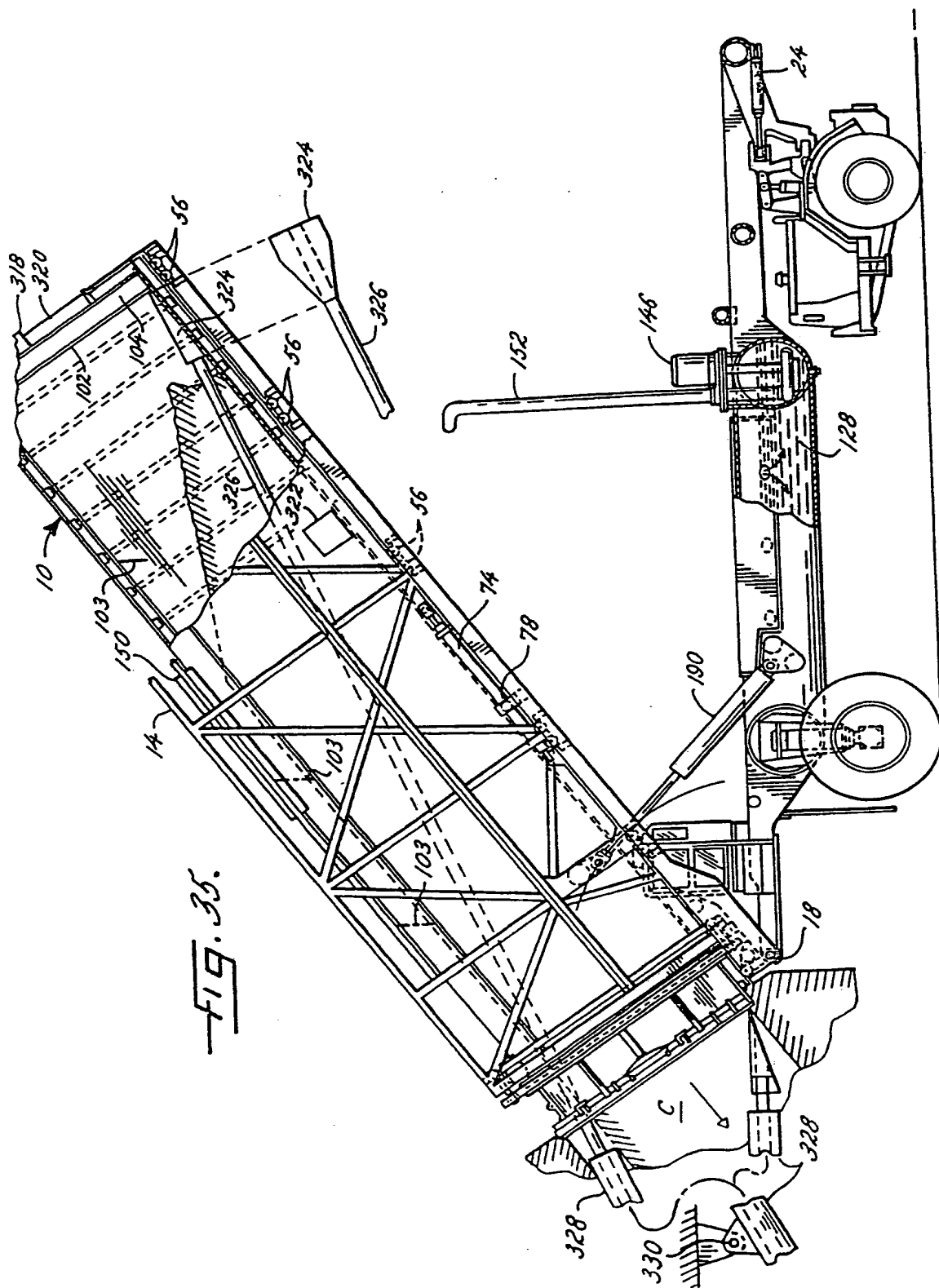


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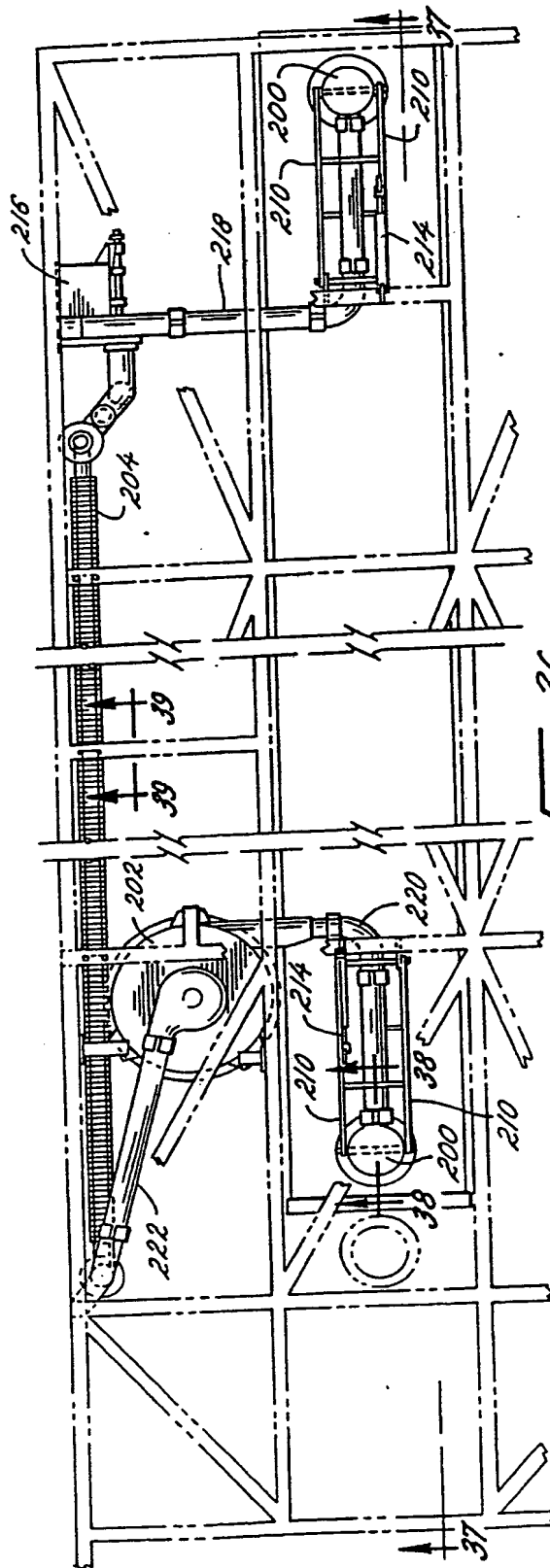


FIG. 36.

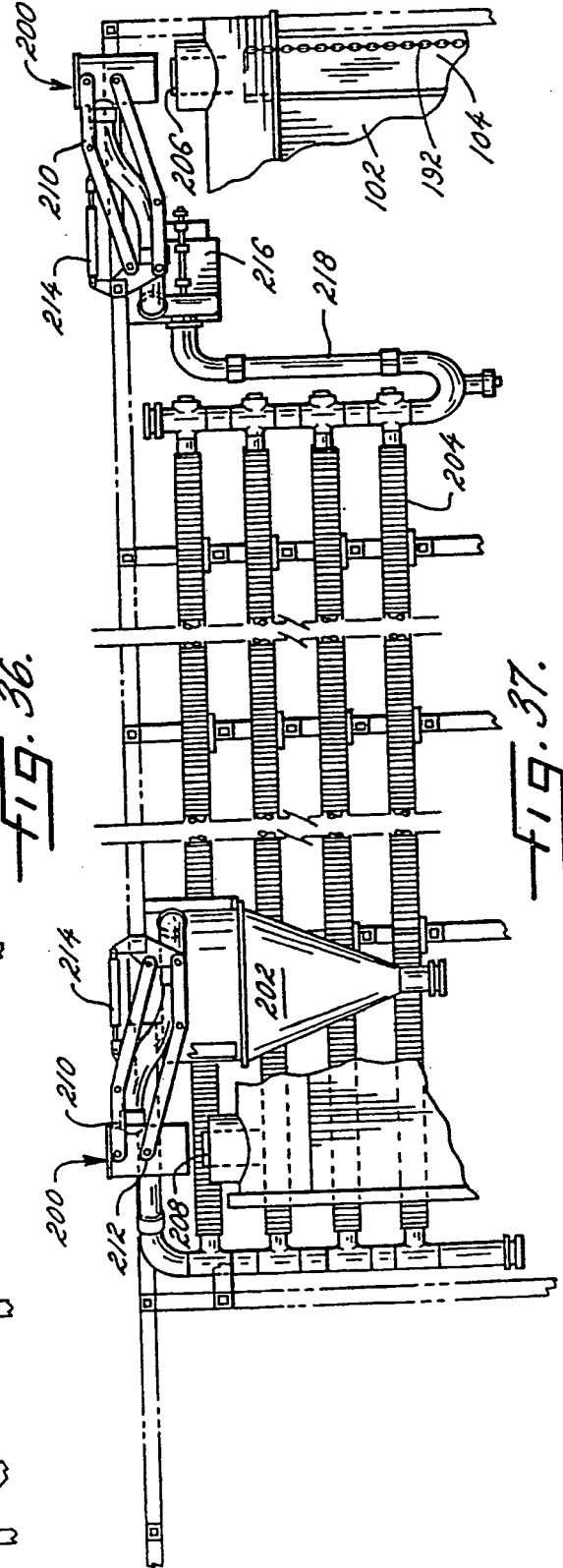


FIG. 37.

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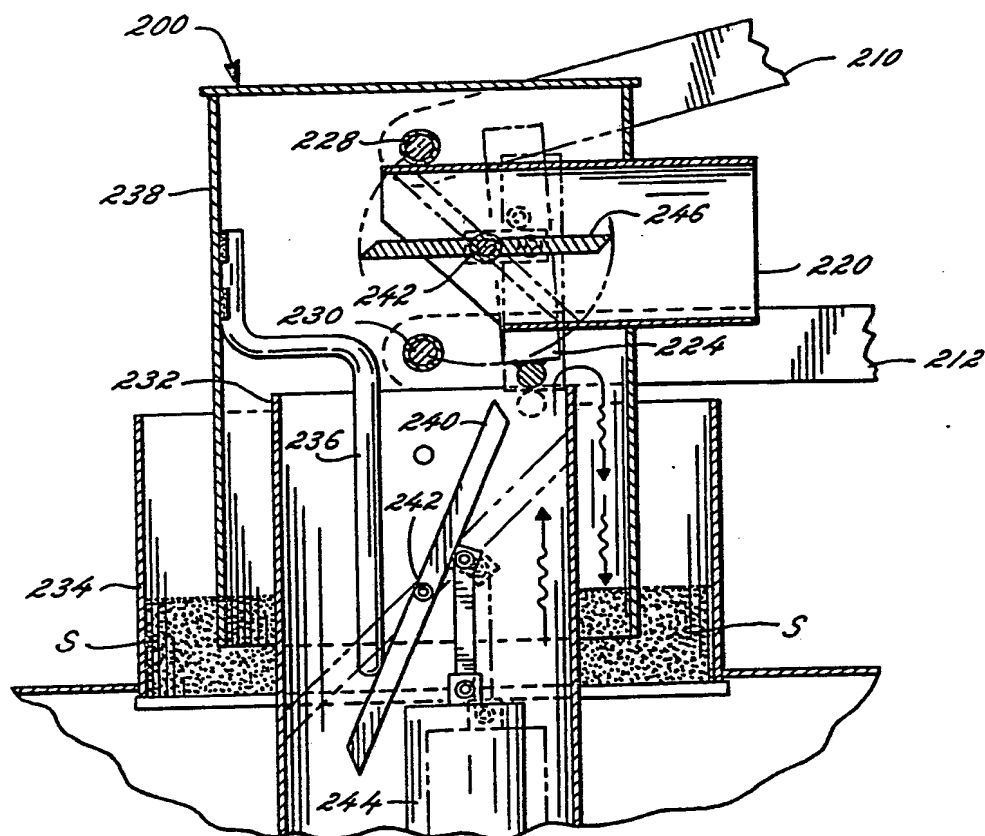


FIG. 38.

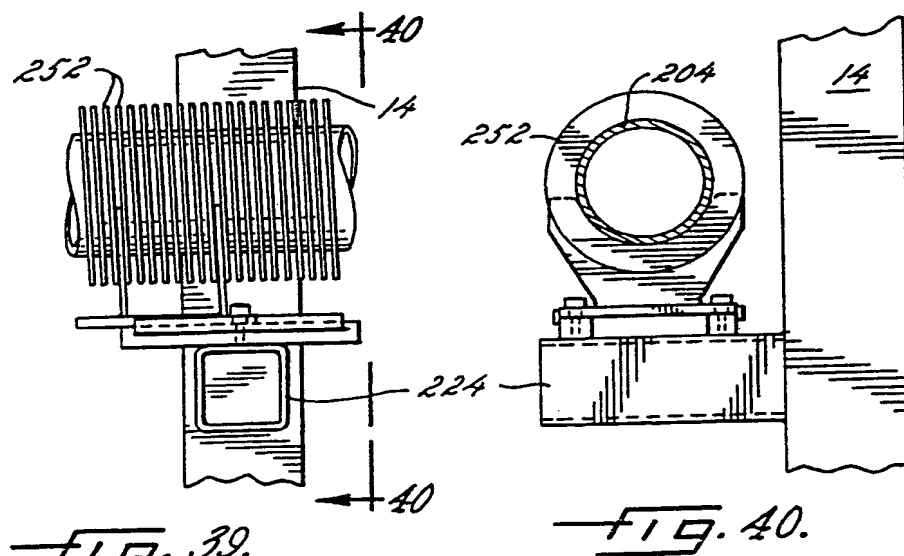


FIG. 39.

FIG. 40.

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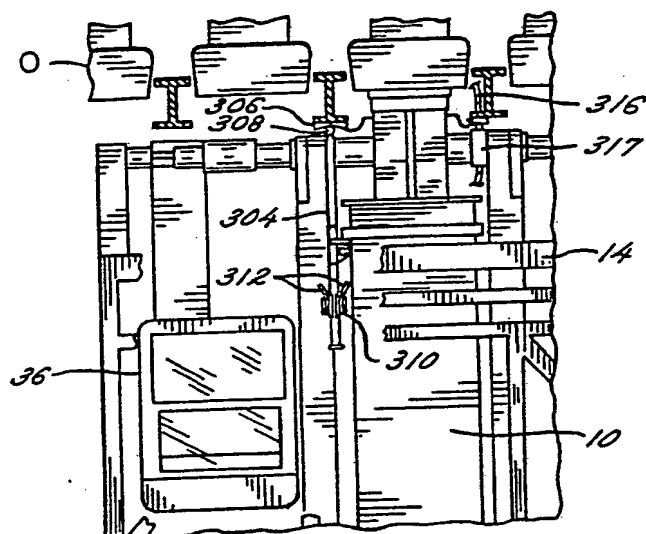


FIG. 41

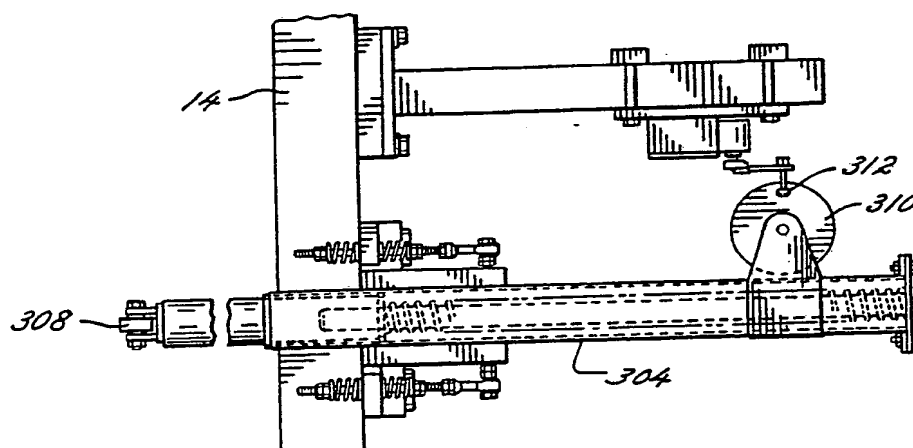
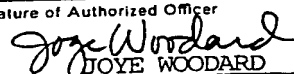


FIG. 42

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/01326

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC IPC (4): C10B 39/02, 39/12; B60P 1/64 U.S. Cl. 201/39; 202/228, 263; 414/498		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
U.S.	201/39; 202/227, 228, 229, 230, 239, 263, 270; 414/401, 477, 478, 498, 536, 584; 34/13, 20; 410/2, 44, 46, 52, 68, 77, 80, 89, 92	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>9</sup>		
Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	US, A, 4,285,772 (KRESS) 25 August 1981, See the entire document.	1, 2, 4, 18
Y	KRESS CORPORATION BROCHURE, "KIDC-COKE PRODUCTION EMISSION CONTROL SYSTEM", 31 July 1981, see the entire document.	1-4, 18,
Y	US, A, 4,274,923 (MAHAR) 23 June 1981, see column 8, lines 14-44.	7
Y	US, A, 4,605,353 (HAHN ET AL) 12 August 1986, see col. 1, lines 5-12.	2
Y	US, A, 4,049,501 (LINDGREN) 20 September 1977, see the entire document.	5, 6
Y	US, A, 4,435,250 (LINDGREN) 06 March 1984, see the entire document.	5, 6
A	US, A, 4,248,671 (BELDING) 03 February 1981, see the entire document.	8, 22
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>*</sup> Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 50%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
29 June 1988		01 AUG 1988
International Searching Authority		Signature of Authorized Officer
TSA/US		 JOYCE WOODARD

## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE<sup>1</sup>

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers \_\_\_\_\_, because they relate to subject matter<sup>12</sup> not required to be searched by this Authority, namely:

2. ☐ Claim numbers \_\_\_\_\_, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out<sup>13</sup>, specifically:

3. ☐ Claim numbers \_\_\_\_\_, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING<sup>2</sup>

This International Searching Authority found multiple inventions in this international application as follows:

I. Claims 1-7, drawn to a carrier vehicle; class 414 subclass 498.

II. Claims 8-17, drawn to a coke box; class 202 subclass 228.

III. Claims 18-21, drawn to a coke handling and quenching apparatus; class 202 subclass 230.

IV. Claims 22-24, drawn to a method for dry quenching coke; class 201 subclass 39.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application. Telephone Practice

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

## Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.  
☐ No protest accompanied the payment of additional search fees.